The Dissertation Committee for Isabel Cristina Victoria-Jaramillo Certifies that this is the approved version of the following dissertation:

A Methodology for the Environmental Justice Assessment of Toll Road Projects

Committee:

C. Michael Walton, Supervisor

Michael Bomba

Randy B. Machemehl

Robert Paterson

Jorge Prozzi

A Methodology for the Environmental Justice Assessment of Toll Road Projects

by

Isabel Cristina Victoria-Jaramillo, B. S.; M.Sc.

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Dedication

To the Almighty who keeps leading my way and to my husband, Elkyn, and daughters, Tatiana and Sophia, for their lovely support and inspiration.

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A Methodology for the Environmental Justice Assessment of Toll Road Projects

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Isabel Cristina Victoria-Jaramillo, Ph.D.

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Supervisor: C. Michael Walton

Environmental Justice (EJ) legislation and regulation are designed to protect the health and welfare of specific populations. Although the importance of environmentally just transportation projects is widely recognized, appropriate documents to guide transportation decision makers in assessing EJ concerns particularly pertinent to tolled facilities are largely unavailable. It is foreseeable that toll road projects could hold additional benefits as well as burdens for EJ communities compared to non-toll road projects. To date, however, very little guidance exists on how to assess the additional benefits and burdens imposed by toll roads compared to non-toll roads, and how to mitigate any negative impacts. The objective of this research was to develop a robust approach for the effective identification, evaluation, and mitigation of disproportionately high impacts imposed on minority and low-income communities (EJ communities) by toll roads relative to non-toll roads given four specific scenarios. The scenarios were conceptualized considering the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. The recommended EJ evaluation methodology

(EJEM) has two equally important components: an analysis/quantitative and an effective EJ participation component.

The analysis component requires the analyst to (1) identify the demographic profile and the spatial distribution of population groups within the impacted area by using an appropriate geographic scale, (2) identify the spatial concentrations of EJ communities in the impacted area, (3) determine the additional impacts of concern associated with the toll road relative to the non-toll road, (4) calculate the magnitude of the additional impacts, (5) determine whether zones with higher concentrations of EJ populations are disproportionately impacted by the toll road, and (6) identify and formulate effective mitigation options if it is found that the impacts on zones with higher concentrations of EJ populations are appreciable more severe than the impacts on zones with lower or no concentrations of EJ populations.

The EJ participation component aims to ensure that EJ communities are given the opportunity for meaningful participation. EJ outreach efforts are foreseen during the various steps of the analysis to ensure that (1) all EJ communities (neighborhoods) are identified, (2) all the adverse impacts are identified and prioritized, (3) the measured impacts are shared with the impacted communities, and (4) effective mitigation options are designed in consultation with the impacted EJ community.

Finally, the products developed in this research provide transportation planners and decision makers with a robust and defendable methodology to address EJ concerns associated with toll road projects in Texas and other U.S. states with similar equity concerns.

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Chapter 1 Introduction

1.1 BACKGROUND

Road infrastructure is a key component of any state's transportation system. It allows unprecedented levels of mobility, accessibility, and economic growth. As in much of the rest of the United States, vehicle miles traveled (VMT) in Texas has been growing faster than the population. Over the last 25 years, the population of Texas increased 57 percent while use of its roads grew 95 percent. During this same time period, the road capacity in Texas increased by only 8 percent. Over the next 25 years, the population of Texas will increase an additional 64% while the use of its roads will increase an additional 214% (Texas Department of Transportation, 2006a). Slightly over 73 percent of the state's annual 229.3 billion VMT occurs on state highways while the remaining 60.7 billion VMT occurs on local roads and streets (Texas Department of Transportation, 2006b). Based on current revenues, the state of Texas can only fund about one-third of its transportation highway growth needs through traditional tax dollars. The state gas tax only pays for 32% of the current transportation budget. As a result, the Texas Department of Transportation (TxDOT) has projected a shortfall of $86 billion in the state transportation budget; funds needed to achieve an acceptable level of mobility by 2030 (Texas Department of Transportation, 2006a).

Increasingly, traditional funding sources are inadequate to maintain and modernize the state's infrastructure to thus ensure mobility, accessibility, and reasonable travel times. One possible option to address this funding shortfall is to finance new roads and the rebuilding and modernizing of existing roads in rural and urban areas through investments that can be recovered from tolls charged to users. A preliminary literature review revealed that more than 26 U.S. states have expanded or modernized their road infrastructure through tollways (Federal Highway Administration, 2005). Tolls are thus becoming an increasingly popular method for state Departments of Transportation (DOTs) to alleviate some of the cost burden of maintaining and building transportation-related infrastructure.

In Texas, toll equity and Regional Mobility Authorities (RMAs) are voter-approved entities created to leverage limited state transportation funds to build needed transportation infrastructure sooner. Toll equity and RMAs are considered key financial tools by Texas Governor Rick Perry. Either loan or grant funds may be granted to the RMAs by TxDOT for the acquisition, construction, maintenance, and operation of a turnpike project. Toll equity allows, for the first time, state highway funds to be used for toll projects without requiring repayment of the funds (Texas Department of Transportation, 2004a). Potential benefits for TxDOT include fiscal savings as RMAs take responsibility for infrastructure project development, infrastructure maintenance, and supplementary revenue sources (Texas Department of Transportation, 2006c). In line with the Governor's vision and given the fiscal constraints of traditional roadway funding sources, the Texas Transportation Commission unanimously approved on December 16, 2003 a policy that directed TxDOT, RMAs, private developers, counties, and regional toll authorities to evaluate the feasibility of tolling all controlled-access mobility projects in any phase of development or construction (Texas Department of Transportation, 2004b). This directive pertained to the following: new facilities, increased capacity (for example, adding frontage roads to existing main lanes), the conversion of existing non-toll roads to toll roads, and the conversion of planned non-toll roads to toll roads. This action fulfills the requirements of Texas House Bill 3588 passed during the 78th Legislature in May of 2003 (see Box 1.1) (Krusee, 2003), but it has also raised questions about tolling and its equitable impact on affected communities known as environmental justice (EJ). Although the importance of environmentally just transportation projects is widely recognized, applicable documents and methodologies to guide transportation decision makers in assessing EJ concerns pertinent to tolled facilities are largely unavailable.

Box 1.1 Texas House Bill 3588

Texas House Bill 3588 addresses the transportation funding shortfall in the State of Texas and expanded the ability of RMAs to construct, maintain, and operate various transportation projects. It also gave TxDOT, RMAs and counties flexibility in deciding whether to develop a non-toll highway as a tolled facility.

1.2 PROBLEM STATEMENT

Inherently, transportation investments almost always create a disparate impact in that benefits are not equally distributed to all communities affected by the investments. Assessing the equity of transportation investments requires the examination of a myriad of issues, including determining who benefits and who is burdened by the proposed transportation projects. Environmental Justice (EJ) becomes an issue when minority or low-income communities (referred to as EJ communities) receive fewer benefits and are either/or disproportionately burdened by transportation investments. The burdens may be the result of negative mobility, social, economic, or environmental impacts placed on those living in the affected toll project areas. It is foreseeable that toll-road projects could hold additional benefits as well as burdens for EJ communities compared to non-toll road projects. To date, however, very little guidance exists on how to assess the additional benefits and burdens associated with toll roads as compared to non-toll roads, much less how to mitigate any negative impacts caused by these projects. Many professionals believe EJ analysis can be achieved through public involvement, but a more comprehensive EJ assessment requires both a qualitative and quantitative analysis. Furthermore, previous research studies have employed statistical analysis to estimate the location of minority and low-income populations in relation to toxic chemical releases, rather than to transportation facilities. These studies have tended to emphasize existing circumstances (e.g., whether minority populations are suffering injustice from a current site) rather than seeking to predict EJ concerns that might occur if a transportation facility were to be constructed (e.g., whether low-income drivers would be disproportionately impacted by the building of a proposed toll road).

1.3 Research Objective

The development of a methodology for the effective evaluation of EJ issues in regard to tolled facilities is not only timely, it is critical. The objective of this research is to develop an approach for the effective identification, evaluation, and mitigation of disproportionately high or adverse effects imposed on minority and low-income communities (EJ communities) by toll roads relative to non-toll roads. The four scenarios considered are the following:

- the conversion of existing non-toll roads into toll roads;
- the construction of new toll roads;
- the conversion of planned non-toll roads into toll roads prior to public access to the road; and
- the conversion of existing non-toll roads into toll roads by (a) tolling the existing lanes and adding adjacent frontage roads as *free alternatives* or (b) tolling the new capacity (i.e., building the toll lanes in the grass median) and keeping the existing lanes as *free alternatives*.

The four toll road scenarios are conceptualized with consideration to the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. The pricing structure for all four scenarios assumes a flat rate (i.e., constant toll irrespective of the day of week, time of day, level of congestion, or number of passengers in the vehicle).

1.4 RESEARCH APPROACH

To achieve the research objective, three major tasks were conceptualized as follows: (1) compile an in-depth literature review, (2) conduct a series of interviews on the topic of toll roads and EJ with community-based organizations and minority and low-income people potentially impacted by the proposed toll road system in Central Texas, and (3) the development of the methodological components to effectively identify, evaluate, and mitigate the EJ aspects of the considered toll scenarios.

1.3.1 Task 1: Literature Review

An in-depth literature review covered the following aspects:

- regulations and guidelines establishing EJ requirements for transportation projects, including criteria defining population groups as EJ communities, and identified EJ concerns pertinent to highway projects;
- ecological, mobility, safety, social, and economic impacts related to toll road projects;
- socio-demographic characteristics of toll road users;
- EJ practices effectively employed in the development of highway projects, including techniques to enhance public outreach;
- methodologies for creating demographic profiles and identifying the spatial distribution of EJ communities at the corridor/project level;
- qualitative and quantitative tools to assess the EJ impacts (e.g., socio-economic, mobility, cultural, ecological effects);

- performance measures, statistical techniques, and power analysis, to determine whether EJ populations are disproportionately or adversely affected by tolled facilities; and
- actions that mitigate or offset disproportionate or adverse impacts imposed on EJ populations by toll road projects.

The insights gained from the literature review aimed to conceptualize the qualitative and qualitative components of the proposed EJ methodology.

1.3.2 Task 2: Interviews

A key component of an effective methodology to analyze the EJ aspects given the four toll-road scenarios is the inclusion of minority and low-income populations in the decision-making process of proposed toll road projects (e.g., in providing input in research and data collection needs, in project design, in determining the benefits and burdens of proposed tolled facilities, and in identifying mitigation measures). Community based organizations and leaders have an extensive understanding of the minority and low-income communities that they serve.

The objective of this task was to conduct a series of interviews on the topic of toll roads and EJ with community-based organizations and minority and low-income groups potentially impacted by the toll road projects planned for Central Texas. The salient findings of a *Telephone* and a *Door-to-Door Survey* conducted between January and April of 2006 allowed upfront the identification of (a) any specific issues of concern to the community pertaining to toll road projects and (b) EJ outreach efforts aim to ensure meaningful representation and participation of minority and low-income individuals by informing and involving them in the process.

1.3.3 Task 3: Development of a Methodology to Effectively Identify, Evaluate, and Mitigate the EJ Aspects of the Studied Toll Scenarios

The objective of this task was to develop the fundamental components of an effective methodology to analyze the EJ aspects given the four toll road scenarios and to then translate them into guidelines in which transportation agencies could consider and use in the preparation of environmental analysis. The recommended EJ evaluation methodology (EJEM) has two equally important components: an analysis/quantitative component and an effective EJ public participation component. The analysis component requires the following:

- to identify the demographic profile and spatial distribution of population groups in the impacted area by using an appropriate geographic scale;
- to identify the spatial concentrations of EJ communities in the impacted area;
- to determine the additional impacts of concern (i.e., environmental quality, mobility, safety, social and economic) associated with the toll road relative to the non-toll road;
- to calculate the magnitude of the additional impacts;
- to determine whether zones with higher concentrations of EJ populations are disproportionately impacted by the toll road; and
- to identify and formulate effective mitigation options if it is found that the impacts on zones with higher concentrations of EJ populations are appreciably more severe than the impacts on zones with lower concentrations of EJ populations.

The EJ public participation component aims to ensure that EJ communities are given the opportunity for meaningful representation and participation in the decision-making process surrounding the proposed toll road project. EJ community outreach efforts are thus foreseen to assure during the various steps of the analysis that (1) all EJ communities (neighborhoods) are identified and given the opportunity to participate in a meaningful way, (2) all the adverse impacts are identified and prioritized, (3) the measured impacts are shared with the impacted EJ communities, and (4) effective mitigation options determined to lessen or offset identified disproportionately high or adverse impacts are designed in consultation with the impacted communities. To reveal core community concerns, public outreach techniques are important in facilitating the dialogue between the transportation agency and the impacted community. In this regard, the transportation agency should first and foremost gain a true understanding of the impacted EJ communities. In addition to gathering basic demographic information and describing who the population is, the transportation agency should improve its knowledge regarding the barriers that prevent meaningful EJ public participation.

1.5 DISSERTATION ORGANIZATION

The dissertation is structured as follows. Chapter 2 highlights key findings of the literature review regarding the regulations that established the requirement for Environmental Justice (EJ) analysis and the definitions for EJ populations. Chapter 3 presents the proposed methodology for the identification, measurement, and mitigation of potential EJ impacts associated with the four defined toll-road scenarios relative to non-toll roads. The scenarios are conceptualized with consideration of the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. The principles underlying the proposed EJ evaluation methodology (EJEM) are presented in this chapter, including the recommended methodological components and sub-components. Chapters 4 to 8 explain the six analyses/quantitative methodological steps of the EJEM as follows:

- Chapter 4: Step 1: Who would be impacted?

- Chapter 5: Step 2: Is there a potential EJ concern?
- Chapter 6: Step 3: What are the additional impacts of concern imposed by the toll road versus the non-toll road?
- Chapter 7: Steps 4 and 5: What is the magnitude of the additional impacts? Are the EJ communities disproportionately impacted by the toll road?
- Chapter 8: Step 6: What are potential mitigation options?

Chapters 9 to 11 explain the EJ Participation component. Chapter 9 provides background information for the development of the effective EJ participation. Chapter 10 outlines the general approach to ensure meaningful EJ public participation at each step of the EJEM while Chapter 11 presents the specific goals of the EJ outreach effort during each stage of the EJEM. Chapter 12 highlights the main conclusions of this research and recommends future research that will enhance the methodology proposed in this study.

Chapter 2 Legal Requirements for Environmental Justice Analysis

An in-depth literature review was conducted of the laws, regulations, and policies establishing the requirement for Environmental Justice (EJ) analysis when considering transportation investments and the criteria for a population group to be considered an EJ community. This chapter of the dissertation provides the overall legal background for Chapter 3. The chapter ends with concluding remarks.

2.1 A Legal Requirement and Administrative Directive

The requirement for environmental justice (EJ) is part of many laws, regulations, and policies, including: (a) Title VI of the Civil Rights Act of 1964, (b) the National Environmental Policy Act of 1969, (c) Section 109(h) of Title 23, (d) the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (URA), as amended, (e) the Transportation Equity Act for the 21st Century (TEA-21), and (f) numerous U.S. DOT statutes. Title VI of the Civil Rights Act states that

> *"[n]o person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance*" (U.S. Department of Justice, 1998).

The Civil Rights Restoration Act of 1987 amended Title VI to require that all activities of federal aid recipients must comply with this non-discriminatory requirement—not just those programs or activities that receive direct Federal aid. Thus, even highway projects that are entirely funded by state or local governments have to comply with this requirement if their agencies receive any federal funding. The U.S. DOT has developed Title VI regulations to ensure that transportation agencies comply with this mandate. An administrative enforcement procedure exists to address any concerns about discrimination in violation of Title VI. Title VI may, however, also be enforced in court (ICF Consulting, 2003). The interpretation of EJ concerns has in recent years been the subject of a number of court decisions. The most important EJ criteria that emerged from Title VI litigation are that plaintiffs should demonstrate intentional discrimination (not only disparate impacts) and be in a position to suggest a reasonable non-discriminatory alternative (Hicks & Company and Rust Environment & Infrastructure, 1997).

On February 11, 1994 President Clinton signed Presidential Executive Order 12898, which requires federal agencies to

> *"make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations."*

Executive Order (EO) 12898 (1994) thus requires "*that minority and low-income populations not receive disproportionately high and adverse human health or environmental impacts.*" Specifically, the EO pointed agencies to the existing regulations contained in the National Environmental Policy Act (NEPA) of 1969,[1] Title VI of the Civil Rights Act of 1964[2], and the laws that require public input and access to information (Hicks & Company and Rust Environment & Infrastructure, 1997). EO 12898 and the accompanying presidential memorandum called for specific actions during the NEPA process (Federal Highway Administration, 2002a), including the following:

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[1]The NEPA process sets policy goals for the protection, maintenance, and enhancement of the environment.

[2] Title VI prohibits discrimination on the basis of race, color, or national origin in programs and activities that receive federal funding.

- analyzing environmental effects (e.g., human health, economic, and social) on minority and low-income populations;
- ensuring that mitigation measures outlined or analyzed in the environmental documents address the disproportionately high and adverse environmental effects of the proposed actions on minority and low-income populations; and
- providing opportunities for community input in the NEPA process by facilitating the attendance of EJ community members to public meetings, providing official documents and notices to affected communities, and by identifying potential effects and mitigation measures in consultation with affected communities.

EO 12898 is, however, an administrative directive and does not create any new legal rights and is not enforceable in court (Hicks & Company and Rust Environment & Infrastructure, 1997).

In response to EO 12898, the U.S. DOT issued DOT Order 5610.2 entitled "Department of Transportation Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (February 3, 1997). The U.S. DOT order stated that "an adverse impact is disproportionately high and adverse on a minority or low-income population when (a) the adverse impact is predominantly borne by a minority population and/or low-income population, or (b) the adverse impact that will be suffered by the minority population and/or low-income population is more severe or greater in magnitude than the adverse impact that will be suffered by the non-minority population and/or non-low-income population" (Novak and Joseph, 1996). Like EO 12898, the DOT order is not a new requirement, but is intended to reinforce the requirements of the existing legal framework as provided by NEPA and Title VI.

In December 1998, the FHWA issued its own order on EJ—"FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (DOT Order 6640.23)—that required the implementation of the principles of EO 12898 and DOT Order 5610.2. The FHWA order specifically stated that the following information needs to be collected and analyzed when considering EJ in terms of FHWA activities: (a) the race/national origin and income of those served and/affected, (b) the proposed steps to protect the identified minorities from disproportionately high or adverse effects, and (c) proposed membership of the identified minorities on any planning or advisory body. The FHWA undertook to adhere to the following steps with regards to its programs, policies and activities to prevent disproportionately high and adverse impacts on environmental justice populations:

a. identify and evaluate the environmental, health, social, and economic effects,
b. propose measures to avoid, minimize, and mitigate disproportionately high and adverse effects, and to provide offsetting benefits and opportunities,
c. consider alternatives, and
d. provide public involvement opportunities (ICF Consulting, 2003).

The discussed orders (i.e., EO 12898, DOT Order 5610.2, and DOT Order 6640.23) encourage agencies to address EJ under the NEPA process. In essence, NEPA requires that the responsible federal agency must evaluate the environmental impacts of every *"major federal action significantly affecting the quality of the human environment."* This requirement applies to projects that receive federal funding or require a type of federal permit. The NEPA statute specifically requires that State DOTs address the following:

- identify social, economic, and environmental effects,
- consider alternatives and mitigation options,

- involve the public and other agencies, and
- use a systematic interdisciplinary approach (ICF Consulting, 2003).

Since the NEPA statute does not explicitly state how EJ impacts should be addressed under the NEPA process, two federal documents (developed by the Council on Environmental Quality (CEQ) and the FHWA Western Resource Center) have attempted to provide guidance for public agencies considering EJ under NEPA. The CEQ provides definitions (i.e., for minority individuals, minority populations, low-income populations) that can be used in assessing EJ, and offers some broad guidance to determine high and adverse impacts. No definite guidance is, however, provided to many of the analytical questions faced by planners. The Interim Guidance on addressing EJ under NEPA developed by the FHWA Western Resource Center provides guidance (a) on appropriate definitions, (b) as to where in the Environmental Impact Assessment (EIA)/Environmental Impact Statement (EIS) is to discuss how minority and low-income groups will be impacted and how they were involved in the decision-making process, (c) in identifying adverse impacts, and (d) as to what defines a disproportionately high and adverse effect. The latter was stated as

> *"... appreciably more severe or greater in magnitude on minority or low-income populations than the adverse effect suffered by the non-minority or non-low-income populations after taking offsetting benefits into account"* (ICF Consulting, 2003).

Finally, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Section 109 (h) of the Federal Highway Act, and both ISTEA and TEA-21 have aspects that aim to promote EJ. The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 aim to ensure uniform and impartial treatment of people and businesses that are displaced by federally funded programs.

Section 109(h) of the Federal Highway Act states "that the appropriate state and federal officials assure that possible adverse economic, social, and environmental effects related to any proposed project on any Federal-aid system have been fully considered in developing the project, and that the final decision on the project is made in the best overall public interest" (Novak and Joseph, 1996). Furthermore, both ISTEA and TEA-21 require strong public participation with Native American Tribal Governments when conducting transportation planning.

2.2 APPLICABLE TEXAS-SPECIFIC STATUTES

The Texas Transportation Commission unanimously approved on December 16, 2003 a policy that directed the Texas Department of Transportation (TxDOT), the Regional Mobility Authorities (RMAs), private developers, counties, and regional toll authorities to evaluate the feasibility of tolling all controlled-access mobility projects in any phase of development or construction (Texas Department of Transportation, 2004b). This directive pertained to the following: new facilities, increased capacity (for example, adding frontage roads to existing main lanes), the conversion of existing non-toll roads to toll roads, and the conversion of planned non-toll roads to toll roads. This action fulfills the requirements of Texas House Bill 3588 passed during the 78th Legislature in May of 2003 to addresses the transportation funding shortfall in the State of Texas and expanded the ability of RMAs to construct, maintain, and operate various transportation projects (Krusee, 2003). It also gave TxDOT, RMAs and counties flexibility in deciding whether to develop a non-toll highway as a tolled facility.

The Texas Administrative Code specifically directs RMAs to develop a toll road project consistent with the NEPA statute by conducting a study of the social and environmental impact of the project (Texas Administrative Code, 2004a). Further, if the toll road project receives federal funds, the environmental studies must be conducted in compliance with the CEQ regulations.

Texas statute prescribes that the Texas Transportation Commission cannot convert a segment of a non-toll road into a toll road unless the public has a "reasonable alternative route on non-toll roads" (Texas Administrative Code, 2004b). Since it is still unclear what this provision entails, it could be the subject of litigation (Torres et al, 2004). Further, before a non-toll road can be converted into a toll road, Texas law requires that the transportation commission first determine that "there is significant public support for the conversion" (Texas Administrative Code Ann., 2004). That is, the Commission is required to determine that the conversion is indeed in the public interest. Again, the phrase "significant public support" is open to interpretation. Unfortunately, the Texas statute is too young to have created any legal precedent (Torres et al, 2004).

Regardless of any legal precedent, FHWA requires involvement of the potentially affected community, including fitting a project harmoniously within a community and ensuring that every transportation project considers the human environment (Federal Highway Administration, 2000). When some adverse impacts are unavoidable, FHWA's objective is to mitigate these impacts by identifying all community concerns early in the planning process and providing offsetting initiatives and enhancement measures to benefit the affected population groups.

2.3 Environmental Justice Population Groups

The terms "minority" and "low-income" were initially defined by the Interagency Working Group (IWG), led by the U.S. Environmental Protection Agency (EPA), which was created to implement the requirements of EO 12898. These definitions were subsequently incorporated in the U.S. DOT and FHWA policies. The definitions have essentially remained unchanged since their inception. In the FHWA policy (Federal Highway Administration, 1998), the terms are defined as follows:

- Minority describes a person who is Black, Hispanic, Asian American, American Indian or Alaskan Native (see Box 2.1);
- Minority Population is "any readily identifiable groups of minority persons who live in geographic proximity, and if circumstances warrant, geographically dispersed/transient persons (such as migrant workers or Native Americans);"
- Low-Income Person describes an individual with a "household income at or below the Department of Health and Human Services poverty guidelines;" and
- Low-Income Population is "any readily identifiable group of low-income persons who live in geographic proximity, and, if circumstances warrant, geographically dispersed/transient persons (such as migrant workers or Native Americans) who would be similarly affected by a proposed FHWA program, policy, or activity."

Box 2.1 Ethnic Origin

Black (not of Hispanic origin): all persons having origins in any of the Black racial groups of Africa
Hispanic: all persons of Mexican, Puerto Rica, Cuban, Central or South American, or other Spanish culture or origin, regardless of race
Asian American: all persons having origins in any of the original peoples of the Far East, Southeast Asia, the Indian Subcontinent, or the pacific Islands. This area includes, for example, China, India, Japan, Korea, the Philippine Islands, and Samoa.
American Indian or Alaska Native: all persons having origins in any of the original peoples of North America, and who maintain cultural identification through tribal affiliation or community recognition.

According to the FHWA (Cambridge Systematics, Inc., 2002), the terms minority and low-income populations "should not be presumptively combined" when analyzing EJ issues. There are minority populations of all income levels, while low-income populations may be minority, non-minority, or a mix in a given area. This research thus analyzes these two population groups separately.

2.4 Concluding Remarks

EJ requires that a transportation agency determine whether a program, policy, project or activity will impact minority or low-income populations disproportionately and ensure that these communities are:

- afforded an opportunity under Title VI to participate in the planning process to ensure a non-discriminatory process,
- involved in the identification of impacts associated with the project in an effort to determine if the effects suffered by these populations are disproportionately high, and
- involved in identifying mitigation and enhancement measures associated with a particular project (Novak and Joseph, 1996).

Very little guidance, however, exists specifically on how to identify and quantify the additional impacts of toll roads on low-income and disadvantaged communities and on how to establish whether an impact is disproportionately high or adverse (e.g., the appropriate geographic scale for identifying the spatial distribution of minority and low-income populations in the impacted area, a quantitative approach to assess whether EJ populations are disproportionately impacted compared to other population groups).

In general, transportation agencies recognize the need for and the clear benefits of EJ community participation in the decision-making process surrounding toll projects, but the tasks are often times more challenging than first anticipated. Effective public participation techniques have been well researched, but the meaningful involvement of EJ communities requires a new perspective and emphasis, partly because conditions needs to be created that encourage the participation of people who likely do not have technical backgrounds or do not have previous knowledge of toll road issues. A distinct approach is thus needed to ensure the meaningful participation of minority and low-income communities in the decision-making process surrounding proposed toll road projects.

Chapter 3 Proposed Methodology for Identifying, Measuring, and Mitigating EJ Concerns of Toll Roads

This chapter presents the proposed methodology for the identification, measurement, and mitigation of potential Environmental Justice (EJ) impacts associated with four defined toll-road scenarios relative to non-toll roads. The scenarios are conceptualized given the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. The principles underlying the proposed EJ evaluation methodology (EJEM) are presented, including the recommended methodological components and sub-components.

3.1 Toll Road Scenario Characteristics

It is generally argued that toll roads have a disproportionate impact on EJ communities if the workplaces of lower-income commuters are not accessible by transit, the economically disadvantaged have to shift to congested roads to avoid the toll, low-income drivers are priced out of traveling for some discretionary trips (e.g., shopping trips and recreational trips), or they are forced to use less attractive modes (e.g., transit, bicycling, or walking) to satisfy their transportation needs (Litman, 2004). Whether a toll is regressive, however, is a function of how many lower-income drivers use the toll facility, the quality of available alternative transportation modes, and how toll revenues are used (Litman, 2004; Litman, 1996; Giuliano, 1994). Contradictory reports regarding the mobility, social, and economic impacts of transportation pricing point to the fact that the EJ analysis of toll roads can be very complex. Table 3.1 summarizes the relevant features of a toll road that may potentially affect EJ outcomes.

Table 3.1 Toll Road Features Relevant for EJ Analysis

Features	Examples
Type of facility	Converting existing non-toll roads into toll roads
Demographic characteristics of the commuter population	High percentage of minority/ low-income travelers and low percentage of high-income travelers
Demographic characteristics of the neighborhood adjacent to the facility	Facility to divide low-income African American neighborhood
Corridor alternatives, including non-auto mode	No non-toll road available Non-toll roads available as "frontage roads" Low frequency of public transit service Slower bus service on congested frontage roads
Access control	Limited access to local minority neighborhoods Improved access to sensitive places (i.e., hospitals)
Toll pricing structure	Flat rate Dynamic rate Differential rate (e.g., low-income commuters pay less than high-income commuters)

Depending on the features of the toll road, distinct ecological, mobility, safety, social, and economic impacts may result. For example, the conversion of an existing non-toll road into a toll road is more likely to have a disproportionate impact on a low-income community living adjacent to the road, especially if residents commute to work by car. Given the cited features in Table 3.1, four toll-road scenarios (see Table 3.2) were conceptualized considering the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. The Commission's tolling policy—aimed at addressing the shortfall in transportation funds in Texas—applies to new location facilities, capacity enhancements (e.g., adding additional main lanes or frontage roads to existing facilities), the conversion of existing non-toll roads into toll roads, and the conversion of planned non-toll roads to toll roads upon completion. The pricing structure for all four scenarios assumed a flat rate (i.e., constant toll irrespective of the day of week, time of day, level of congestion, or number of passengers in the vehicle).

Table 3.2 Toll Road Scenario Characteristics

Scenario Characteristics	Scenario 1	Scenario 2
Location	Existing location (existing road)	New location (new road)
Alternative non-toll road within the same right-of-way	No	Not applicable
Planned/Constructed	As a non-toll road	As a toll road
Operated	Initially operated as a non-toll road. Non-toll road converted into a toll road after a period of time.	As a toll road
Scenario Characteristics	**Scenario 3**	**Scenario 4**
Location	New location (new road)	Existing location (existing road)
Alternative non-toll road within the same right-of-way	Not applicable	Yes (frontage roads)
Planned/Constructed	As a non-toll road	As a non-toll road
Operated	As a toll road	Initially operated as a non-toll road. After a period of time, (a) tolling the existing lanes and adding adjacent frontage roads as non-toll alternatives or (b) tolling the new lanes built in the grass median and keeping the existing lanes as non-toll alternatives. In both cases, the new capacity is provided within the same right-of-way.

Texas law states that the Texas Transportation Commission cannot convert a segment of a non-toll road into a toll road unless the public has a “reasonable alternative route on non-toll roads” (Texas Administrative Code, 2004b). Since it is still unclear what this provision entails, Scenario 1 was conceptualized without non-toll road alternatives within the same right-of-way. Scenario 4 assumes adjacent frontage roads as the non-toll alternative within the same right-of-way. Finally, this provision does not apply to Scenarios 2 and 3 as these represent new facilities.

3.2 ENVIRONMENTAL JUSTICE EVALUATION METHODOLOGY

In general, an EJ analysis is required when the following two conditions exist: (1) an EJ population is located in the impacted area, and (2) the adverse impacts caused by a transportation investment could affect the EJ population disproportionately. This requires that the scoping part of the NEPA process be expanded to ensure that minority and low-income populations participate in investment decisions and that opportunities are provided for them to become informed and voice their concerns. This research has conceptualized an EJ evaluation methodology (EJEM) to assess the EJ concerns associated with the four defined toll-road scenarios. The principles underlying the EJEM are (a) the qualitative and quantitative approach for assessing "disproportionately high and adverse effects" imposed by a toll road on EJ communities relative to a non-toll road project and (b) the "meaningful" involvement of minority and low-income populations in the decision-making process surrounding proposed toll road projects.

Many professionals believe EJ analysis can be achieved through public involvement. However, a more correct EJ assessment requires both a qualitative and quantitative analysis (e.g., for identifying impacts imposed on an EJ community by a proposed toll road that it is concerned about, for measuring and comparing the additional impacts imposed on an EJ community by a toll road relative to a non-toll road project). Meaningful involvement is motivated by the fact that:

- EJ communities often face higher environmental risks and burdens associated with a transportation investment due in part to their limited political influence and resources to participate in the decision-making process (National Environmental Policy Commission, 2003).
- EJ communities have the right to be informed and involved in the decision-making process surrounding toll road projects.

- EJ community individuals should understand the critical decision points where their input can make a difference.
- EJ community individuals should understand how the proposed toll road impacts them and their communities and the importance for them to voice their concerns.
- The outcome (e.g., the proposed toll road and the mitigation options) should address the concerns expressed by EJ communities.

In general, transportation agencies recognize the need for and the obvious benefits of EJ community participation in the decision-making process surrounding toll projects, but the tasks are often times more challenging than first anticipated. The research provides a robust and defendable methodology that transportation planners and environmental coordinators can use to achieve a win-win situation for both the impacted EJ communities and the transportation agency.

The proposed methodology has two equally important components: an analysis/quantitative and an effective EJ participation component (see Figure 3.1). The analysis component requires the analyst to:

- identify the demographic profile and the spatial distribution of population groups within the impacted area by using an appropriate geographic scale,
- identify the spatial concentrations of EJ communities in the impacted area,
- determine the additional impacts of concern associated with the toll road relative to the non-toll road,
- calculate the magnitude of the additional impacts,
- determine whether zones with higher concentrations of EJ populations are disproportionately impacted by the toll road, and finally

- identify and formulate effective mitigation options if it is found that the impacts on zones with higher concentrations of EJ populations are appreciably more severe than the impacts on zones with lower or no concentrations of EJ populations.

The second component, EJ participation, aims to ensure that EJ communities are given the opportunity for meaningful participation. A key component of the EJEM is the inclusion of minority and low-income populations in the planning process, in providing input in research and data collection needs, in project design, in determining the benefits and burdens of proposed facilities, and in identifying mitigation measures. EJ outreach efforts are thus foreseen during the various steps of the analysis to ensure that (1) all EJ communities (neighborhoods) are identified, (2) all adverse impacts are identified and prioritized, (3) the measured impacts are shared with the impacted communities, and (4) effective mitigation options are designed in consultation with the impacted EJ community. Public outreach techniques are important to facilitate the dialogue between the transportation agency and the impacted community to reveal core community concerns. In this regard, the transportation agency should first and foremost gain a true understanding of the impacted EJ communities. In addition to gathering basic demographic information that describes the population, the transportation agency should better its knowledge regarding the obstacles that prevent meaningful EJ public participation.

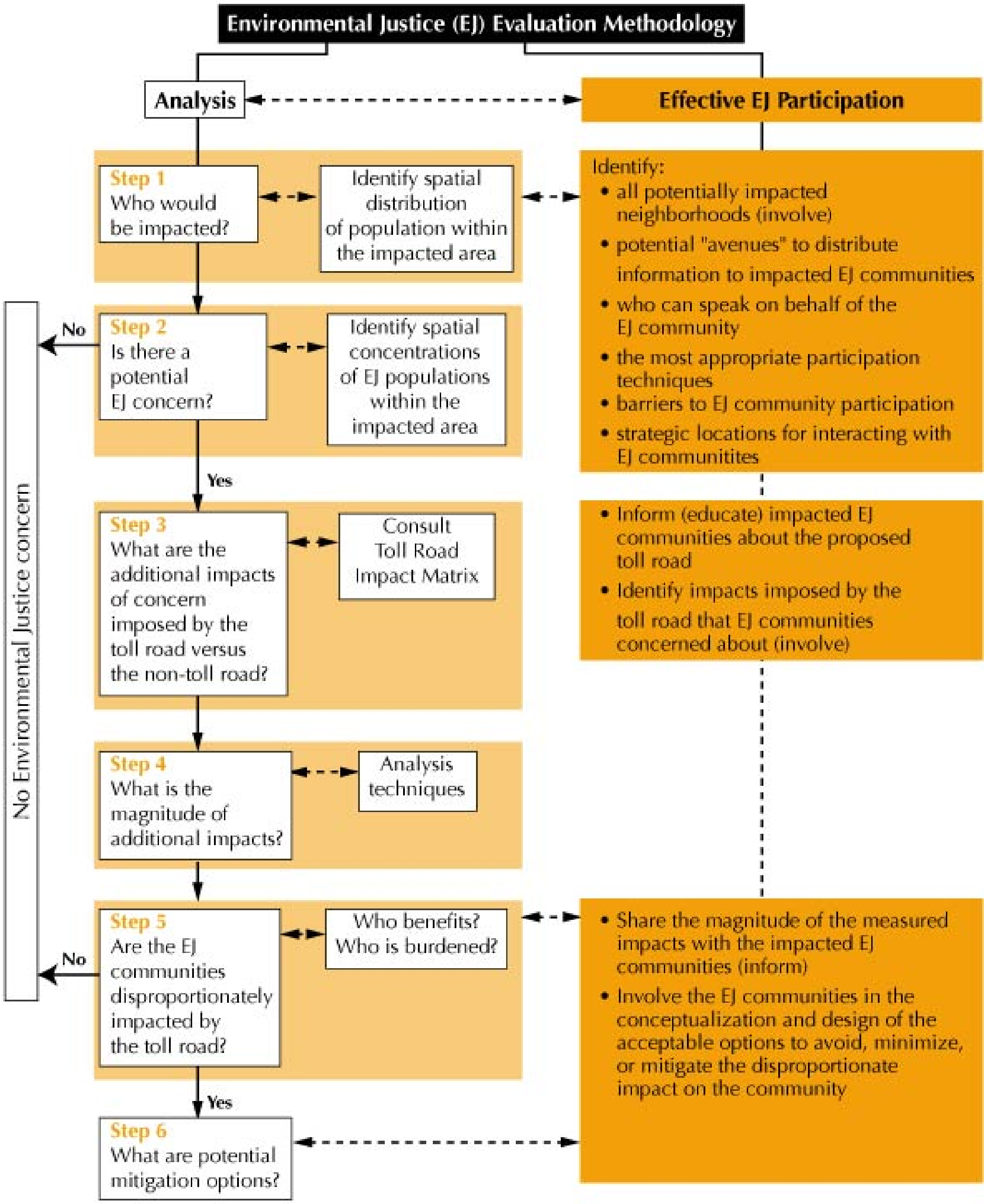

Figure 3.1 Environmental Justice Flowchart for Toll-Road Projects

Chapter 4 Step 1: Who Would be Impacted?

This chapter presents the development of the first analysis/quantitative methodological step of the proposed Environmental Justice Evaluation Methodology (EJEM): **Who would be impacted?** (see Figure 3.1). The chapter includes background information, the elements required for identifying the spatial distribution of the impacted population groups at the corridor/project analysis level, and the results of a sensitivity analysis to assess how different geographic scales influence the spatial distribution of EJ communities impacted by a proposed toll road (*sensitivity analysis of different geographic scales*). The development of this quantitative component required to examine the content and geographic scales of the U.S. census products, including the variable that are relevant for EJ analysis, and estimate an econometric model to assess the low-income populations at the block level by using available U.S. census data at the block group level (*block-low-income model*). The mentioned analyses (i.e., the *sensitivity analysis of different geographic scales* and the *block-low-income model*) were tested using data for the section of the SH 130 toll road that traverses Travis County, Texas. The results and findings from the empirical applications are presented. The chapter ends with concluding remarks.

4.1 WHO WOULD BE IMPACTED?

The first step in the analysis/quantitative component of the EJEM is the identification of the population affected by the proposed toll road (see Figure 3.1). The literature revealed that the greatest impacts are typically to those communities residing close to a transportation facility. For example:

- Children living near busy roads are more likely to develop all types of cancer (Pearson et al., 2000).
- Pregnant women living near high traffic areas are more likely to have premature and low-birth weight babies (Wilhelm and Ritz, 2002).
- Low-income persons tend to experience higher levels of pedestrian accidents and traffic pollution, because they often live adjacent to busy roads (Social Exclusion Unit, 2002).
- Motor vehicle air toxins cause high pollution levels inside homes (Buchan et al., 2003).
- Minority and low-income persons are more likely to live near freight facilities and therefore may be disproportionately impacted because their neighborhood are exposed to high concentrations of diesel emissions which have been related to higher airborne cancer risk (ICF Consulting, 2003).

Research studies have concluded that there is a link between traffic related air pollution and health risk. Air pollutants cause numerous adverse health effects including cancer, asthma, and heart attacks. Asthma is exacerbated by pollution from trucks and cars. The main cancer-causing pollutants from trucks and cars are diesel particular matter (PM) and volatile organic compounds (VOCs). Motor vehicles are the most significant source of ultra-fine particles, which have been linked to increase in mortality and mobility. Four studies citing the health risk to children and adults living near roads and busy highways are the following:

- A study in Denver, Colorado, revealed that children living within 230 meters of a road with 20,000 or more vehicles per day are six times more likely to develop all types of cancer and eight times more likely to get leukemia. The study attributes most of this risk to the VOCs in motor vehicle exhaust (Pearson et al, 2000).

- A study in Erie County, New York, found that children living in neighborhoods with heavy truck traffic within 200 meters of their homes had increased risks of asthma hospitalization (Lin et al, 2002).
- Studies conducted in the vicinity of Interstates 405 and 710 in Southern California found that people who live near the freeways are exposed to 25 times more ultra-fine particles and that pollution levels gradually decrease back to normal levels around 300 meters from the highway (Zhu et al, 2002).
- An air pollution study that measured diesel particulates near mobile and idling trucks at the West Oakland Port, California, showed that motor vehicle air toxins cause high pollution levels inside homes. The level of diesel particulates inside these homes were five time the level of diesel particulates that people were exposed to outdoors in other areas of Oakland (Palaniappan and Wu, 2003).

In addition, toll roads may also impact the activity space where communities work, shop, and partake in other activities. For example, the conversion of an existing non-toll road into a toll road may reduce access to medical services and job opportunities for those who cannot afford the toll charged. The literature review revealed the following interesting observations regarding the socio-demographic characteristics of toll road users in California:

- The user demographics of the variable-toll express lanes in the median of the Riverside Freeway (State Route 91) in Orange County, California, revealed that (1) high-income earners are more than twice as likely to use toll lanes as low-income earners (23 percent compared to 10 percent), and (2) low-income earners are more than twice as likely not to use toll lanes as high-income earners (37 percent compared to 73 percent) (Sullivan, 1998). This points to a strong correlation between income and the frequency of toll lane use.

- A public opinion survey of the dynamic priced[3] I-16 High Occupancy Toll (HOT) lanes in San Diego, California, revealed strong support across all income groups (The Fairfax Research Group, 2001). Counter-intuitively, the lowest income group expressed stronger support than the higher income group (80 percent compared to 70 percent). According to DeCorla-Souza and Skaer (2003), this strong support by the poor may be explained by the fact that while higher income earners generally have more flexible work schedules, poorer workers typically have either work schedules or childcare arrangements that require them to be on time. Tolled facilities thus allow them to bypass congestion and avoid severe consequences at work and childcare.
- A Southern California study showed that a 5¢ per mile road user fee would produce benefits to all residents by reducing congestion and air pollution (Cameron, 1994). Furthermore, it was concluded that the toll would mostly benefit the poorest residents, who tend to live near busy roads and therefore are most exposed to pollution.

Finally, a California study that investigated five categories of transportation pricing measures in the Los Angeles, Bay Area, San Diego, and Sacramento metropolitan regions found that (1) the lowest income class made relatively little use of the highway system, (2) the lower middle class endured much of the impact of pricing policies, and

[3] Dynamic pricing means that the toll rate fluctuates according to the amount of traffic actually on the road during that particular time of day. Generally, electronic message boards are used to display user fares.

(3) the distribution of impacts are more strongly correlated to income than to demographic characteristics (Deakin and Pozdena, 1996).

The literature reviewed revealed only one case study where a tolled facility would have a perceived disproportionately high impact on a minority community. The equity analysis for converting the I-95 high occupancy vehicle (HOV) lane into a high occupancy toll (HOT) lane in South Florida disclosed a disproportionately high impact on members of the African American community who make short trips (i.e., trips less than 10 miles) (Cleland and Winters, 2000).[4]

Finally, Forkenbrock and Sheeley (2004) concluded that in order to assess the nature and magnitude of impacts that vary spatially throughout a community, it is first necessary to gain a sense of the geographic space within which population groups live and move (i.e., spatial activity).

4.2 IDENTIFY THE SPATIAL DISTRIBUTION OF POPULATIONS WITHIN THE IMPACTED AREA

Figure 4.1 illustrates the elements required for identifying the spatial distribution of the impacted population groups at the corridor/project analysis level.

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[4] Commuter acceptance and equity analysis of the HOT Lanes/Value Pricing concept for the I-95 in South Florida was tested through a telephone survey among residents of the three-county South Florida area (Palm Beach, Broward, and Miami-Dade counties).

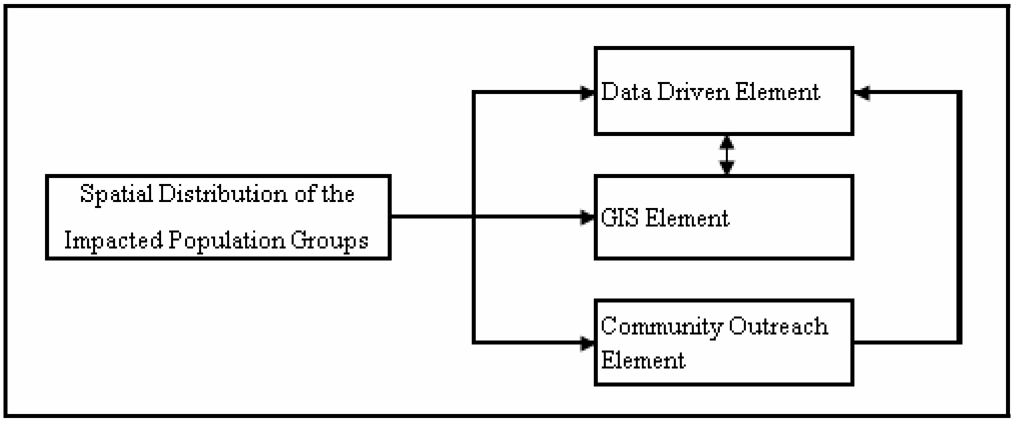


Figure 4.1 Elements for Identifying the Spatial Distribution of Impacted Population Groups

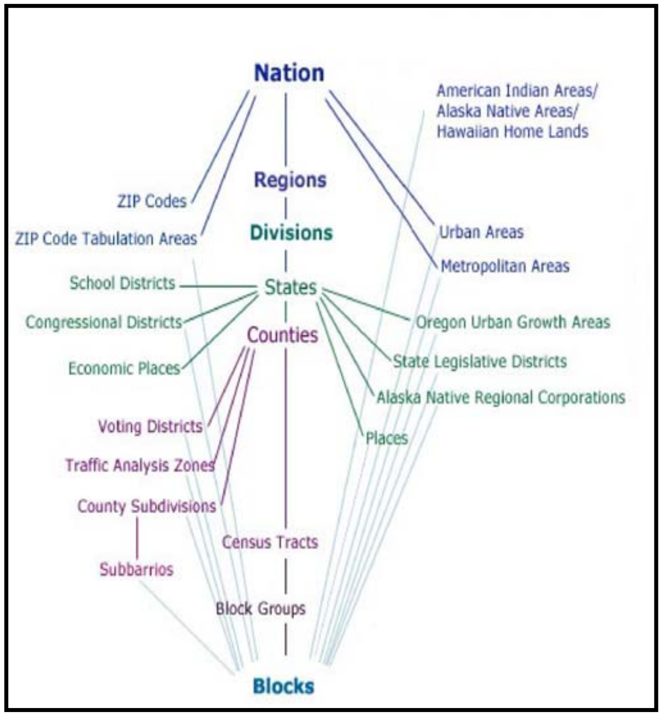
The U.S. Census Data and Geographic Information Systems (GIS)-based techniques have proven to be very useful in developing demographic profiles (see Table 4.1) at very disaggregate levels of geographic detail (e.g., census block, grids). Agencies that administer federal income sensitive programs, such as food stamps, section 8 housing, and free/reduced price meals, may be valuable sources of local demographic data. Structured community outreach efforts are also needed to ensure detailed information about minority and low-income population that live within geographic areas that are not aligned with census data. Information regarding small pockets of EJ populations may be obtained from churches, community centers, and by visual inspection of the study area. A special effort must be made to engage all the neighborhoods affected by the proposed action to ultimately enhance the EJ analysis of toll road projects.

Table 4.1 Expertise Required for Developing Demographic Profiles

Method	Assessment Level	Appropriate uses	Use When	Data needs	Expertise required
Threshold Analysis	Screening/ Detailed	Regional Plans, STIP/TIP, Initial Corridor Assessment	Demographic patterns must be evaluated for large areas	Low	GIS, Census Data
Spatial Interpolation	Screening/ Detailed	Corridor/ Project Level	Demographic patterns must be evaluated for small areas or population patterns must be evaluated for finite areas of effect	Medium	GIS, Census Data
Population Surfaces	Detailed	Regional Plans/ Corridor/ Project Level	Scenario modeling or integration with grid-based modeling packages is required	High	GIS, Census Data
Environmental Justice Index	Screening/ Detailed	All	Combined analysis of multiple demographic factors is needed	Medium/ High	GIS, Census Data

Source: Adapted from Forkenbrock and Sheeley (2004)

Since the 1990 and 2000 U.S. Census Data are reported at different geographic scales (see Figure 4.2), the data may be used for different levels of analysis. When identifying impacted population groups at the project level, the scale of geographic analysis selected requires special consideration. The selected scale should provide detailed information about the population characteristics within the impacted area. According to a Cambridge Systematics, Inc. study (2002), counties and census tracts are usually employed for statewide planning; census tracts, census block groups, Traffic Analysis Zones (TAZs) and neighborhoods are used for metropolitan planning; and census block groups, census blocks, or individual households are used for project development.



Source: 2000 U.S. Census Data

Figure 4.2 Census Geographic Hierarchy

Forkenbrock and Sheeley (2004) recommended the following scale of geographic analysis when using U.S. Census Data:

- large-area census data (i.e., states, counties, and census tracts) for both the initial assessment of corridor studies and when the scale of effects is assumed to be uniform over the impacted area, and
- small-area census data (i.e., block, block group, and TAZs) for both detailed corridor-level and project-level assessment and when the scale of effects requires a high degree of demographic resolution because impacts are not uniform over the impacted area.

Box 4.1 summarizes the findings of a recent MPO survey regarding the scale of geographic analysis used by MPOs for EJ analysis for their Long-Range Transportation Plans (Lederer et al., 2005).

Box 4.1 Scale of Geographic Analysis Used by MPOs for EJ Analysis

A survey conducted from June to September 2003 of the EJ analysis methodologies used by MPOs for their Long-Range Transportation Plans provides insight into the scale of geographic analysis adopted by the 64 MPOs that responded. The responses, summarized in the table below, show that (1) there is no standard approach in terms of the scale of census data used for the identification of EJ communities, (2) smaller MPOs do not necessarily use the more aggregate geographic scale (i.e., census tracts), and (3) larger MPOs tend to use TAZs, because the output from their travel demand models allow them to determine the mobility and accessibility impacts on EJ communities at the TAZ level.

Geographic Scale	% of MPO responses		MPO Population Mean	
	For Identifying Minority Populations	For Identifying Low-income Populations	For Identifying Minority Populations (Million Inhabitants)	For Identifying Low-income Populations (Million Inhabitants)
Block	16	*	0.62	------
Block Group	21	34	1.10	0.93
Tracts	32	31	0.93	0.87
TAZ	17	20	2.50	2.40
Undefined	14	15		
TOTAL	100	100		

*Income or poverty data are not compiled at the census block level.

Source: Lederer et al (2005)

Through the results of a *sensitivity analysis of different geographic scales*, this research demonstrates that the geographic scale (i.e., census tract, block, block group, and TAZs) adopted for identifying the EJ communities could potentially affect the spatial distribution of these population groups in the impacted area. The selection of a proper geographic scale can be invaluable when determining whether protected population groups are disproportionately high and adversely affected by toll road projects.

4.3 SENSITIVITY ANALYSIS OF DIFFERENT GEOGRAPHIC SCALE

This research presents the results of a sensitivity analysis that is performed to assess how different geographic scales (i.e., census tracts, block groups, blocks, and

Tabs) influence the spatial distribution of EJ communities potentially impacted by a proposed toll road. The sensitivity analysis was applied to the proposed SH 130 toll road in Travis County, Texas. The sensitivity analysis is conducted in five stages as explained below.

First, the contents and geographic scale of U.S. Census data products relevant for EJ analysis are presented, including the variables captured by these products which can be useful in identifying EJ populations.

Second, because income data is not available at the Census block level, an income model, the *block-low-income model*, is estimated to address this gap when conducting EJ analyses of toll road projects that require a high degree of demographic resolution.

Third, the U.S. Census Data and GIS-based techniques are used for developing the demography profiles and the spatial distributions of the population groups in the impacted area for the study geographic scales. Using a threshold approach, the target EJ communities are identified by comparing the demographics of the impacted area with the demographics of a more general area (referred to as the community of comparison or COC). Threshold values (percentages) are calculated by dividing the minority and low-income populations in the COC by the total population in the COC. The various EJ populations are mapped at the different geographic scales using vector models. The vector models display the spatial distribution of the target and non-target population groups by dividing the impacted area into polygons (i.e., tracts, block groups, blocks, and TAZs). Tracts, block groups, blocks, and TAZs with minority/low-income populations greater than an established threshold are considered to have a target population group. On the other hand, tracts, block groups, blocks, and TAZs with minority/low-income populations lower than the established threshold are considered not to have a target population group.

Fourth, statistical analyses are conducted to compare the proportions of EJ and non-EJ populations among the various study scales. Homogeneity tests are undertaken to test whether the true proportions of the population groups are identical for the four study scales. In this case, there are *I* geographic scales (I = 4) and the population is divided into the same *J* population groups (J=2). The null hypothesis states that the proportion of individuals in population group *j* is the same for each geographic scale, and that this is true for all population groups. Therefore, for every *j*, $p_{i1} = p_{2j} = \ldots = p_{ij}$. The test statistic is as follows:

$$\boxed{If \quad \chi^2 \geq \chi^2_{\alpha,(I-1)(J-1)}, reject\ H_0\ at\ level\ \alpha\ test}$$

Inferences about target population proportions were conducted to assess the statistical significance of the difference between target population proportions. In this case, P_1 and P_2 denote the true proportions of individuals in population groups 1 and 2, respectively, which exhibit a particular characteristic (i.e., target low-income individual or target minority individual). The null hypothesis is: H_o: $p_1 - p_2 = 0$. When H_o is true the standardized variable *Z* has an approximate standard normal distribution. The test statistic is as follows:

$$\boxed{If\ either\ Z \geq Z_{\alpha/2}\ or\ Z \leq -Z_{\alpha/2}, reject\ H_0\ at\ level\ \alpha\ test}$$

Fifth, correlation coefficients are estimated to assess the direction and strength of the relationship between minority and low-income populations in the impacted area for the four geographic scales. This coefficient can be calculated as follows:

$$\boxed{r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}}$$

where d is the difference between observation pairs and n is the number of pairs. This simple formula will provide a good approximation to r_s when the number of ties in the ranks is small.

Finally, the relevant findings and conclusions from the sensitivity analysis are presented.

4.3.1 Relevant Census Data for Environmental Justice Analysis

Table 4.2 summarizes the contents and geographic scales of U.S. Census data products relevant for Environmental Justice (EJ) analysis. The Redistricting File (PL-94-171) and Summary File 1 (SF 1) contain data (100 percent) obtained from the short census form. The Summary File 3 (SF 3) contains a weighted sample—weighted to represent the total population—of data collected from the long census form. The Census Transportation Planning Package (CTPP) 2000—the data is also from the long census form—is a set of special tabulations not found in any other decennial census product. These four products are available free of charge from numerous sources, including online from the U.S. Census Bureau and federal repository libraries.

Table 4.3 summarizes the variables captured by the census data products, which can be useful in identifying EJ populations.

Table 4.2 Census Data Products Relevant for Environmental Justice Analysis (2000)

Census Product	Contains	Geographic Scale
Census 2000 Redistricting Data File (PL-94-171)	• Location of the population by race and ethnic origin, and location of population over the age of 18 by race and ethnic origin. • Six single race tabulations (African American, American Indian/Alaska Native, Native Hawaiian and other Pacific Islander, Asian, White, and some other race). Fifty-seven combinations for those that marked more than one of the six race categories.	• Census Block • A TAZ field included in the redistricting file allows users to aggregate blocks into TAZs.
Summary File 1 (SF 1)	• Population variables include age, sex, race, ethnic origin, household type, household relationship and group quarters. • Household data include occupancy status, vacancy status, and tenure status (owner occupied or renter occupied).	• Census Block (171 population tables and 56 housing tables) • Census Tract (56 population tables with detailed race and ethnic origin data)
Sample Summary File 3 (SF 3)	• Population data include age, mobility limitation status, ancestry, occupation, citizenship, place of birth, class of worker, place of work, educational attainment, poverty status, ethnic origin, sex, household type and relations, travel time to work, income, urban and rural population, veteran/military status, language spoken at home, work disability status, marital status, work status, means of transportation to work, and workers in family. • Housing data include age of householder, race of householder, ethnic origin of householder, telephone availability, vehicle availability, selected monthly owner costs, condominium status, tenure, units in structure, housing units, value of housing unit, mortgage status, occupancy status, and rent.	• Census Block Group • Census Tract
Census Transportation Planning Packages (CTTP)	• Tabulations by place of residence (Part 1), place of work (Part 2), and worker travel patterns between residence and workplace (Part 3). • 120 tables by place of residence; 66 tables by place of work; and 14 tables related to the flow between home and work (i.e., summaries of the home and work locations of workers). • Housing data include housing size, housing income, and vehicles per household. • Worker data include age and gender of workers, occupation of workers, and worker earnings. • Transportation mode data include usual mode to work, commuting time, and work trip departure time. • Work data include work location and time of arrival at work.	• TAZ for those counties that have a TAZ layer defined in Tiger/Line. For other metropolitan areas, the lowest level of detail is the tract or block group, depending on the choice of the local MPO.

Table 4.3 Relevant Census Data Variables for Identifying EJ Populations

Population Group	Variable	Census Data Products		
		PL 94-171	SF 1	SF 3
Minority	Total population: Hispanic or Latino	PL002002	P004002	P007010
	Total population: Not Hispanic or Latino; Black or African American alone	PL002006	P004006	P007004
	Total population: Not Hispanic or Latino; American Indian and Alaska Native alone	PL002007	P004007	P007005
	Total population: Not Hispanic or Latino; Asian alone	PL002008	P004008	P007006
	Total population: Not Hispanic or Latino; Some other race alone	PL002010	P004010	P007008
	Total population: Total	PL002001	P004001	P007001
Population Group	**Variable**	**SF 3**		
		Total	**Income in 1999 below poverty level**	**Income in 1999 at or above poverty level**
Low-Income	White alone for whom poverty status is determined	P159A001	P159A002	P159A010
	Black or African American alone for whom poverty status is determined	P159B001	P159B002	P159B010
	American Indian and Alaska Native alone for whom poverty status is determined	P159C001	P159C002	P159C010
	Asian alone for whom poverty status is determined	P159D001	P159D002	P159D010
	Some other race alone for whom poverty status is determined	P159F001	P159F002	P159F010
	Total population: Total	P087002	P087002	P087010

4.3.2 *Block-Low-Income Model*

It is foreseen that some toll road projects—either because of the scope of work or because impacts are not uniformly distributed among those affected—would require a higher degree of demographic resolution when conducting EJ analysis. Because the U.S.

census does not capture income data at the census block level, this research estimates a model, using available U.S. census data at the block group level, to estimate low-income populations at the block level. This is possible because there is a perfect correlation between block groups and blocks (i.e., block groups are made up of blocks). A limitation of this imputation technique is that predicted values cannot be compared with observed values.

The econometric approach to develop the *block-low-income model* is as follows: (a) the socio-demographic variables that prove a correlation with the number of people in poverty are identified, (b) the "best" ordinary least-square (OLS) model is estimated, (c) relevant analysis is undertaken to determine spatial dependence, and (d) if the latter exists, better estimates are constructed by incorporating spatial effects into the regression analysis. To test the validity of the methodology, the econometric approach is applied to a section of SH 130 toll road in Travis County, Texas. The methodology, empirical results, and relevant findings from the case study are presented below.

4.3.2.1 Ordinary Least-Square Regression Analysis

The OLS regression model aims to predict the low-income population at the census block level through a best-fit of specified explanatory variables. Using blocks as the unit of geographic analysis, a benchmark model can be defined as follows:

(1) $\mathrm{I}_i = K_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots + \varepsilon_i \quad \textit{(single observation)}$

(2) $\mathrm{I} = K + \beta X + \varepsilon \qquad \textit{(set of observations)}$

where:

I_i = number of individuals below the specified poverty level in block i (i =1,…,n)
K_o = constant
X_{ki} = value of the k_{th} explanatory variable observed for block i

β_k = coefficients representing the numerical effect on I_i resulting from a unit increase in the explanatory variable (X_{ki})

ε_i = residual representing the difference between the actual values and the estimated values of the explanatory variables and their coefficients

To estimate the model, available demographic data from the U.S. census at the block group and block levels were identified. As stated, the model was developed at the block group level because (a) low-income population data (i.e., the number of individuals below the poverty level) is available at the block group level, and (b) there is a perfect match between block groups and blocks. Several models were tested to ensure that the final model is theoretically sound and performs well statistically. Estimation commences with a broad specification of all potential explanatory variables. Given this broad specification, incremental changes are tested to improve the model's realism and empirical fit to the data. The incremental changes involve alternative variable specifications (e.g., summing variables) and deleting variables that are not statistically significant. The following statistic is used to compare two models, where one is a restricted version of the other:

$$\boxed{If \quad F_{STATISTIC} = \frac{(SSE_R - SSE_{UR})/\#\ of\ restrictions}{SSE_{UR}/(n-m)} > F_{(\alpha, v_1, v_2)},\ reject\ H_0}$$

where:

SSE_R = sum of the squared errors of the restricted model
SSE_{UR} = sum of the squared errors of the unrestricted model
n = number of observations (i.e., number of blocks within the impacted area)
m = number of parameters of the unrestricted model

The number of restrictions varies depending on the number of constraints imposed on the unrestricted model to get the restricted model. The F test-statistic is calculated to determine whether to accept or reject the null hypothesis of no difference between the restricted model and the unrestricted model. The critical value for determining whether to reject the null hypothesis depends on:

- the alpha-level (α)
- the number of numerator degrees of freedom (v_1 = number of restrictions)
- the number of denominator degrees of freedom ($v_2 = n$).

Once the "best" OLS model was estimated, tests for spatial dependence was undertaken because the OLS estimates are sensitive to the specification of the model and the existence of spatially correlated estimation errors. OLS assumes that all observations are independent. However, if there is correlation among the observations (i.e., the observations are not independent), the estimated number of degrees of freedom may be too high, while the estimated standard errors may be too low (Anselin, 1988). This may result in some coefficients being considered significant when they are not. If spatial autocorrelation exists in the residuals, the model will overestimate the observed values in some blocks and underestimate the observed values in other blocks. Therefore, given the presence of spatial dependence, estimates can be improved by developing a model that accounts for spatial autocorrelation (Odlund, 1988).

4.3.2.2 Examining the OLS Residuals

Two kinds of spatial effects are discussed in the literature: spatial dependency and spatial heterogeneity. The former occurs when observations that are spatially closer are more related than observations that are spatially distant. If spatial dependency (i.e., spatial autocorrelation) is present in the data, the OLS parameters are not efficient and significance tests are unreliable (Anselin & Griffith, 1988; Miron, 1984). The latter occurs because of a lack of homogeneity across space, a lack of association among the variables under study, or both. In the presence of spatial heterogeneity, the estimated parameters of the spatial model are inadequate descriptors of the situation at any given location (Anselin & Getis, 1992).

Local Indicators of Spatial Association (LISA) were used to reveal the spatial patterns of heterogeneity in the OLS residuals (Anselin, 1995) across the impacted area. The following indicators were calculated (Anselin, 2003a):

- The Moran scatter plot, illustrating the Moran's I statistic and the different types of spatial autocorrelation
- The LISA cluster map, showing the clustering spatial patterns
- The LISA significance map, showing the p-values of the clustering spatial patterns.

The *Moran scatter plot* consists of four quadrants illustrating the residuals within the impacted area by type of spatial autocorrelation. The upper right and lower left quadrants contains the residuals with positive spatial autocorrelation (i.e., can be high-high or low-low). The lower right and upper left quadrants contain the residuals with negative spatial autocorrelation (i.e., can be high-low or low-high). Moran's Index (*I*) for spatial autocorrelation can be applied to regression residuals as follows:

$$\boxed{I = \left(\frac{n}{S}\right)\left(\frac{\varepsilon' W \varepsilon}{\varepsilon' \varepsilon}\right)}$$

where:

n = number of observations (i.e., number of blocks within the impacted area)
ε = vector of the OLS residuals
W = the n x n spatial weight matrix
S = standardized factor equal to the sum of all elements in the weight matrix

The value of *I* ranges from –1 for negative spatial autocorrelation to 1 for positive spatial autocorrelation, and with 0 meaning no spatial autocorrelation. The statistical test to accept or reject the null hypothesis of no spatial dependence is based on the standard normal distribution as follows (Anselin, 1988):

$$\boxed{Z_I = \frac{I - E(I)}{\left[V(I)\right]^{1/2}}}$$

where:

E(I) = the mean of the Moran statistic
V(I) = the variance of the Moran statistic

The analysis of spatial dependence in regression residuals is complex because the residuals are imperfect estimates of the unobserved error terms (Anselin, 1988). A permutation procedure based on a Monte Carlo type test was used to assess the significance of Moran's *I* statistic relative to the stated null hypothesis. Because the Monte Carlo procedure can result in slightly different results between replications (Anselin, 1986; Anselin, 2003a), several replications were required to obtained stable results.

The *LISA cluster map* shows where the residuals are clustered. The *LISA significance map* shows the significant locations by type of spatial autocorrelation. If the model produces residuals with a definite spatial pattern, the model is under- or overestimating the true values. High values (i.e., large positive residuals) indicate model under-prediction. In other words, the "actual" block-low-income is higher than would be estimated by the explanatory variables. Low values (i.e., large negative residuals) indicate model over-prediction. In other words, the "actual" block-low-income is lower than would be predicted by the explanatory variables.

4.3.2.3 Spatial Models

The spatial lag and spatial error models present two basic approaches to incorporate spatial effects into a regression model. Although the two model specifications are closely related mathematically, they have very different interpretations (Kim et al, 2001). In this analysis, the *spatial lag model* assumes that the number of low-income individuals in a specific block is affected by the spatially weighted average number of low-income individuals in neighboring blocks in addition to the explanatory variables that capture the housing characteristics. The *spatial error model* assumes that certain explanatory variables are omitted and that the omitted variables vary spatially. The spatial pattern in the omitted variables results in the error term of the OLS model being spatially autocorrelated.

Spatial Lag Model

The spatial lag *block-low-income model* can be written as follows:

(3) $$\mathrm{I} = \rho W\mathrm{I} + K + \beta X + \varepsilon$$

where:

I = vector of the number of low-income individuals at the block level
ρ = spatial autocorrelation parameter
W = n x n spatial weight matrix (n = number of blocks within the impacted area)
K= constant
X = matrix with observations on block characteristics
ε = vector of independently and identically distributed error terms

Essential to this analysis is the spatial weight matrix, which enables the calculation of the spatial lag, a weighted average of the dependent variable at neighboring blocks. Because of the endogenous nature of the spatial lag term (WI), the OLS parameter estimators are biased and inconsistent for the spatial lag model. Instead, the Maximum

Likelihood Method (MLM) was used for parameter estimation to account for spatial autocorrelation in the independent variables (Ord, 1975; Anselin, 1988).

Spatial Error Model

When spatial dependence is present in the error term, a spatial error model can be estimated using a spatial autoregressive specification. The block-low-income spatial error model can be written as follows:

$$\text{(4)} \qquad \begin{aligned} \mathrm{I} &= K + \beta X + \varepsilon \\ \varepsilon &= \lambda W \varepsilon + \nu \end{aligned}$$

where:

λ = the spatial autoregressive coefficient
W = n x n spatial weight matrix
ν = a vector of independently and identically distributed error terms with constant variance

The spatial error model suggests that the number of individuals below the poverty level (in any block) is a function of the specific block's characteristics and the omitted variables at the neighboring block level. The MLM is used for parameter estimation to account for spatial autocorrelation in the error terms (Anselin, 1988). The OLS estimates of the regression coefficients remain unbiased in the spatial error model, but would have no longer been efficient (Anselin, 1988).

Spatial Weight Matrix

A binary connectivity matrix (i.e., the spatial weight matrix) is constructed to define the spatial relationship among blocks based on the rook's case and the higher order of contiguity. Rook's case refers to the boundary share. In other words, neighboring geographical units have to share a boundary with a length greater than zero.[5] The higher

[5] The rook's case (i.e., the length of the boundary share among neighboring geographical units must be greater than zero) might, however, not necessarily be the best approach to define the spatial interaction

order contiguity weights remove redundancies and circularities in the weight calculations that are undesirable when specifying and estimating econometric models (Anselin and Smirnov, 1996). The components of the spatial weight matrix can be represented as follows:

$$\boxed{c_{jk} = \begin{cases} 1 & \text{if blocks } j \text{ and } k \text{ are contiguous}, \ j \neq k \\ 0 & \text{otherwise} \end{cases}}$$

The weight matrix that is used for detecting spatial dependence is standardized such that the row elements sum to one. The elements of this row standardized weight matrix take non-zero values only for those pairs of blocks that are contiguous to each other. This facilitates the interpretation of the model coefficients, but it adds complexity to the estimation and testing procedures (Anselin, 1988). The standardized weight matrix can be represented as follows:

$$\boxed{w_{jk} = \frac{c_{jk}}{c_{j.}}}$$

$$\boxed{c_{j.} = \sum_k c_{jk.}; \quad \sum_j w_{jk} = 1}$$

where:

w_{jk} = spatial weight between neighboring blocks j and k

$c_{j.}$ = the row sum of the binary connectivity matrix

The standardized weight matrix represents how much each neighboring block contributes to the low-income population in the block of concern by assuming that each neighboring block exerts the same influence on the block of concern. For example, for a

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among blocks. For example, the interaction could also be defined as a function of the shared boundary length between neighboring blocks. Such alternative specifications should be tested by means of sensitivity analyses.

block surrounded by four neighboring blocks, the spatial lag will be the weighted average for the four neighboring blocks, where each has an equal weight of 0.25. For EJ analysis, assigning the same weight to each neighboring block implies that the surrounding blocks exerts the same influence on the low-income population in the block of concern. Furthermore, a higher influence (weight) is assigned to small geographic blocks compared to large geographic blocks when the former is surrounded by fewer neighboring blocks than the latter. This aims to disclose spatial patterns in blocks regardless of their geographic size.

Spatial Hypothesis Testing

Because blocks are used as the unit of geographic analysis, spatial dependence between two blocks, j and k, can be written as follows:

$$\boxed{\begin{array}{l}\operatorname{cov}\left[I_j, I_k\right] \neq 0 \\ \operatorname{cov}\left[\varepsilon_j, \varepsilon_k\right] \neq 0\end{array}}$$

Using the estimated residuals from Equation (2), tests for the presence of spatial dependence either in the form of an endogenous spatial lag or in the form of residual spatial autocorrelation are conducted. The two null hypotheses are:

$$\boxed{\begin{array}{ll}H_0 : \rho = 0 & [lag] \\ H_{0^*} : \lambda = 0 & [residual]\end{array}}$$

via a Lagrange Multiplier (LM) test that is distributed as follows:

$$\boxed{LM = nR^2 \sim \chi_1^2}$$

where:

R^2 = the unadjusted coefficient of determination for the regression of the estimated residuals in Equations (3) and (4), respectively
n = number of blocks in the impacted area.

4.3.2.4 Empirical Results

The *block-low-income model* was estimated using data pertaining to the proposed SH 130 toll road segment in Travis County, Texas. Because SH 130 is expected to impact a sizable area adjacent to the corridor, the impacted area was defined as a 6-mile wide buffer along the proposed alignment. According to the Final Environmental Impact Statement for SH 130 (U.S. Department of Transportation & Texas Department of Transportation, 2001), this area covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (the potential EJ concerns) associated with the proposed road.

The first step in the model evaluation was to identify socio-demographic variables available at both the census block group and block levels from the U.S. Census data products that could explain the number of low-income individuals in the impacted area. Secondly, several regression models were computed using the OLS estimation approach and the "best" OLS model was chosen. Subsequently, a number of indicators were calculated to test for spatial dependence in the observed values and OLS residuals. The Moran's *I* statistic showed that the assumption of independently distributed residuals was not violated. A close examination of the spatial distribution of the regression residuals, however, revealed significant clusters of low-income populations in three census blocks. The spatial lag and error models were estimated to account for the spatial pattern in the final model.[6] This section of the report presents the empirical results and the conclusions.

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[6] GeoDa™ – software to conduct exploratory spatial data analysis (ESRA) – was used to analyze and visualize global and local measures of spatial autocorrelation in the residuals and to incorporate spatial regression terms in the *block- low-income* regression model.

Potential Explanatory Variables

Socio-demographic variables available at both the census block group and block levels were identified from the Census 2000 Summary File (SF 1). Based on the literature and prior knowledge about the impact of certain variables on an individual's income, pertinent assessments were conducted to identify the potential explanatory variables.

Using U.S. historical poverty data (U.S. Census Bureau, 2005b), Spearkman's correlation coefficients were estimated to assess the relationship between (a) all people in poverty and related children under 18 years old, and (b) all people in poverty and people over 65 years old. The analysis, based on U.S. data from 1959 to 1999, showed that (a) there is a strong and positive correlation between poor people and the presence of children (i.e., the coefficient was equal to 0.975 and statistically significant at the 0.01 level), and (b) poor people are positively high related to the presence of elderly people (i.e., the coefficient was equal to 0.724 but not statistically significant at the 0.01 level). Based on the previous results, two census variables (i.e., households with one or more persons under 18 years and households with one or more persons over 65 years) were pre-selected as potential explanatory variables.

The American Housing Survey for 2001, conducted by the U.S. Department of Housing and Urban Development and the Census Bureau, and the Residential Energy Consumption Survey conducted by the U.S. Department of Energy, revealed that 46% of all poor households own their homes (Rector and Johnson, 2004). Because of this interesting finding related to poverty households in America (compared to other countries), tenure status (i.e., ownership) was considered in the initial OLS model specification.

A research study that reviewed the empirical evidence on the level and trend of family/household income inequality in over 20 wealthy nations showed that the well-being of an individual is affected by the income sharing unit (i.e., household unit or family unit) (Gottschalk and Smeeding, 1999). For example, in a household unit (which includes all individuals in a common residence), individuals may benefit from economies of scales but may be unlikely to share incomes. In a family unit (which includes all persons in the residence related by blood or marriage), individuals may share income, benefit from economics of scale, or both. Based on these findings, U.S. census variables that capture family and non-family household sizes were considered in the preliminary OLS model specification.

Finally, the U.S. Census revealed that poverty rates vary by race and Hispanic origin (Bishaw, A., and Iceland, J., 2003). In 1999, poverty rates were higher among American Indians and Alaska Natives (25.7%), African Americans (24.9%), and Hispanic or Latino (who may be of any race) (22.6%) compared with the national average (12.4%). Poverty rates for Asians (12.6%) and Native Hawaiians or Other Pacific Islanders (17.7%) were somewhat higher than the national average while Non-Hispanic Whites had the lowest poverty rate (8.1%). Based on these findings, U.S. census race variables were also considered in the preliminary OLS model specification.

A preliminary OLS model was estimated using the pre-selected explanatory variables. The adjusted R^2 was equal to 0.892. The collinearity diagnostics revealed an ill-conditioned cross-product matrix (i.e., multiple eigenvalues close to zero), meaning there is a problem with multicollinearity[7] (see Table 4.4). Applying the rule of thumb (i.e., condition index over 15 indicates a possible multicollineary problem and a condition

[7] Collienarity (or multicollinearity) is the undesirable situation when one independent variable is a linear function of other independent variable.

index over 30 indicates a serious multicollineary problem), the variables with condition indexes close to or less than 30 were selected. Table 4.5 lists the explanatory variables that were considered in estimating the OLS model.

Table 4.4. Collinearity Diagnostics

Variable	Eigenvalue	Condition Index
Constant	18.961	1.000
Households with one or more people under 18 years	1.74	3.301
Households with one or more people over 65 years	0.949	4.471
Occupied housing units: owner occupied	0.786	4.912
2-person family households	0.505	6.125
3-person family households	0.413	6.775
4-person family households	0.373	7.131
5-person family households	0.249	8.720
6-person family households	0.238	8.926
7-or-more person family households	0.208	9.553
1-person non-family households	0.165	10.725
2-person non-family households	0.112	13.027
3-person non-family households	0.083	15.080
4-person non-family households	0.068	16.652
5-person non-family households	0.062	17.502
6-person non-family households	0.029	25.379
7-or-more person non-family households	0.019	31.563
Hispanic or Latino	0.013	38.121
White alone	0.009	44.504
Black or African American alone	0.007	51.500
American Indian and Alaska Native alone	0.004	69.194
Asian alone	0.002	95.698
Native Hawaiian and Other Pacific Islander alone	0.008	103.576
Some other race alone	0.001	121.497
Two or more races	0.0001	403.674

Table 4.5 Potential Explanatory Variables

Variable (Code)		Variable Name
Households with one or more persons under 18 years (P019002)		HH-W-18Y
Households with one or more persons over 65 years		HH-W-65Y
Occupied housing units: owner occupied (H004001)		HHT-OWOC
Family households (P026002)	2-person households (P026003)	HH-F-2
	3-person households (P026004)	HH-F-3
	4-person households (P026005)	HH-F-4
	5-person households (P026006)	HH-F-5
	6-person households (P026007)	HH-F-6
	7-or-more person households (P026008)	HH-F-7M
Non-family households (P026009)	1-person households (P0260010)	HH-NF-1
	2-person households (P0260011)	HH-NF-2
	3-person households (P0260012)	HH-NF-3
	4-person households (P0260013)	HH-NF-4
	5-person households (P0260014)	HH-NF-5
	6-person households (P0260015)	HH-NF-6
	7-or-more person households (P0260016)	HH-NF-7M

Multiple Regression Model

Eight OLS models were estimated and relevant comparisons were made between restricted and unrestricted models (see Table 4.6). A number of alternative variable specifications were tested, such as: family households with two or more persons (HH-F-2M), family households with four or more persons (HH-F-4M), non-family households with two or more persons (HH-NF-2M), and non-family households with three or more persons (HH-F-3M).

Table 4.6 *Block-Low-Income Model* Specifications

Variable	Model 1		Model 2		Model 3		Model 4	
	B	t-value	B	t-value	B	t-value	B	t-value
CONSTANT	26.469	0.684	45.836	1.103	54.456	1.326	50.913	1.33
HH-W-18Y	3.502	2.005	2.459	1.412	2.674	1.536	1.751	8.186
HH-W-65Y	0.531	0.516	2.431	2.538	2.566	2.686	1.974	3.643
HH-OWOC	-0.841	-2.803	-1.195	-5.727	-1.151	-5.585	-1.103	-6.049
Family households:								
HH-F-2	0.994	1.026	-0.593	-0.787	-0.981	-1.454	-0.977	-1.525
HH-F-3	-3.867	-1.632						
HH-F-4	-2.078	-1.059						
HH-F-5	-3.388	-1.201						
HH-F-6	1.471	0.519						
HH-F-7M	2.363	0.700						
HH-F-2M			-0.657	-0.401	-0.802	-0.488		
HH-F-4M								
Non-family households:								
HH-NF-1	-0.467	-0.488	-0.716	-0.829	-0.775	-0.896		
HH-NF-2	4.676	1.741	2.167	0.84				
HH-NH-3	-3.626	-0.438						
HH-NF-4	2.250	0.123						
HH-NF-5	-37.408	-1.105						
HH-NF-6	17.099	0.471						
HH-NF-7M	25.656	0.517						
HH-NF-3M			9.233	1.776				
HH-NF-2M					3.847	1.812	2.979	2.092
Adjusted R^2	0.839		0.751		0.749		0.759	
SSR	1,390,391.20		1,231,146.30		1,216,847.30		1,207,299.10	
SSE	129,881.75		289,126.63		303,425.69		312,973.92	
SST	1,520,272.95		1,520,272.93		1,520,272.99		1,520,273.02	
			Model 1 vs. Model 2		Model 1 vs. Model 3		Model 1 vs. Model 4	
SSE(restricted)			289,126.63		303,425.69		312,973.92	
SSE(unrestricted)			129,881.75		129,881.75		129,881.75	
# of restrictions			8		9		11	
N			35		35		35	
M			17		17		17	
Fstat			2.76		2.67		2.31	
Fcrit (.05, # restrict, *n*)			2.22		2.16		2.07	
Conclusion:			Reject Ho Model 1 is preferred		Reject Ho Model 1 is preferred		Reject Ho Model 1 is preferred	

Table 4.6 *Block-Low-Income Model* Specifications (continued)

Variable	Model 5		Model 6		Model 7		Model 8	
	B	t-value	B	t-value	B	t-value	B	t-value
CONSTANT	44.829	1.471	47.325	1.557	44.275	1.532	68.743	1.776
HH-W-18Y	3.602	3.116	3.785	3.316	3.362	10.684	1.897	9.107
HH-W-65Y	0.977	1.478	0.933	1.414	0.763	1.577	1.824	3.677
HH-OWOC	-0.772	-4.075	-0.897	-5.855	-0.906	-6.070	-1.278	-8.972
Family households:								
HH-F-2	1.014	1.334	1.396	2.017	1.482	2.294		
HH-F-3	-3.912	-2.187	-4.469	-2.584	-3.953	-3.662		
HH-F-4	-2.390	-2.135	-2.945	-2.881	-2.663	3.790		
HH-F-5	-2.335	-1.013						
HH-F-6	-1.303	-6.100						
HH-F-7	1.996	0.957						
HH-F-2M								
HH-F-4M			-0.444	-0.386				
Non-family households:								
HH-NF-1								
HH-NF-2								
HH-NF-3								
HH-NF-4								
HH-NF-5								
HH-NF-6								
HH-NF-7								
HH-NF-3M								
HH-NF-2M								
Adjusted R^2	0.855		0.855		0.859		0.732	
SSR	1,358,138.40		1,345,152.50		1,344,186.10		1,148,392.80	
SSE	162,134.60		175,120.49		176,086.89		371,880.16	
SST	1,520,273.00		1,520,272.99		1,520,272.99		1,520,272.96	
	Model 1 vs. Model 5		Model 5 vs. Model 6		Model 6 vs. Model 7		Model 7 vs. Model 8	
SSE(restricted)	162,134.60		175,120.49		176,086.89		371,880.16	
SSE(unrestricted)	129,881.75		162,134.60		175,120.49		176,086.89	
# of restrictions	7		2		1		3	
N	35		35		35		35	
M	17		10		8		7	
Fstat	0.64		1.00		0.15		10.38	
Fcrit (.05, # restrict, *n*)	2.29		3.27		4.12		2.87	
Conclusion:	Fail to reject Ho Model 5 is preferred		Fail to reject Ho Model 6 is preferred		Fail to reject Ho Model 7 is preferred		Reject Ho Model 7 is preferred	

Table 4.7 shows the "best" OLS model (Model 7). Some key observations regarding this model include the following:

- The explanatory variables are very significant determinants of number of low-income individuals at the block group level as is evident from the large t-statistic values. All explanatory variables are statistically significant at the 95 percent confidence level (critical $t_{0.05,\ 35} = 2.030$), except the variable that represents households with one or more persons over 65 years which is statistically significant at the 85 percent confidence level (critical $t_{0.15,\ 35} = 1.472$).
- The explanatory variables provide a fairly high level of explanation. Roughly 86 percent of the observed variation in the number of low-income individuals at the block group level is explained by the simple linear regression model relationship between the dependent variable and the explanatory variables.
- The signs of the explanatory variables were as expected. The number of low-income individuals increases as the number of households with persons under 18 and over 65 years, and the number of two-person family households increases. On the other hand, the number of low-income individuals decreases as the number of housing units that are occupied by owners and family households with three and four-person increases.
- In terms of the magnitude of the coefficients, the "households with one or more persons under 18 years" and the "three-person family households" variables have the most significant coefficients.
- Unequal variance in the regression errors (i.e., heteroskedasticity) is suggested by the highly significant White test (critical $\chi^2_{0.05,6} = 12.59$).

Table 4.7 Best "OLS" Model

Variable	Coefficient (β)	t-value	Condition Index
Constant	44.275	1.532	1.000
Households with one or more people under 18 years	3.362	10.684	4.095
Households with one or more people over 65 years	0.763	1.577	6.969
Occupied housing units: owner occupied	-0.906	-6.070	16.152
2-person family households	1.482	2.294	22.584
3-person family households	-3.953	-3.662	28.350
4-person family households	-2.663	3.790	46.299
Adjusted R^2 =	0.859		
SSR (residual sum of the squares) =	1,344,186		
SSE (error sum of the squares) =	176,087		
SST (total sum of the squares) =	1,520,273		
F-level =	35.62 (p-value < 0.05)		
White test =	22.466		

- The condition indexes of the family household size variables revealed multicollineary.[8] Although the regression coefficients are not biased, the heteroskedasticity and multicollinearity conditions indicate that the estimates of the regression coefficients may fluctuate drastically from one sample to the next. To gauge how much estimation variation or instability was due to collinearity, seven regression equations were estimated using a reduced number of randomly selected cases. Subsets contained between 90% and 95% of the original cases. The results revealed that instability was not a serious problem. Compared to the "best" OLS, the signs of the parameter estimates did not change, the magnitude of the parameters changed by 20% or less, and the parameters were statistically significant at the 95 percent confidence level,

[8] It may be a sample problem, in which case new data may cause the problem to disappear. If multicollineary is not a sample problem, the model can be used with all its variable but sufficient care should be given to the interpretation of the regression results

except the variable that represents households with one or more persons over 65 years which was statistically significant at the 80 or 85 percent confidence levels.

Examination of the Residuals

The *normal probability plot* of the dependent variable (see Figure 4.3) suggests that the assumption of normally distributed residual error is met and therefore, statistical significance tests may be reliable. Under perfect normality, the plot will be a 45-degree line.

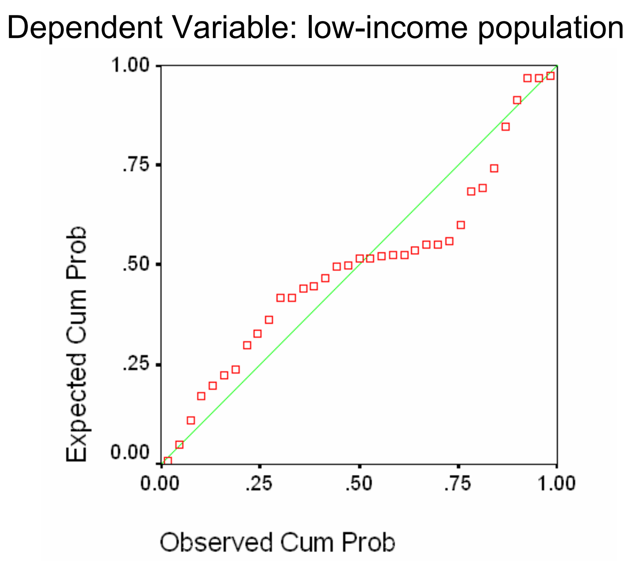

Figure 4.3 Normal P-P Plot Regression Standardized Residual

The Moran scatter plot (see Figure 4.4) shows the residuals within the impacted area by type of spatial autocorrelation (i.e., high-high, high-low, low-high, low-low). The Monte Carlo test was applied using 999 permutations to test the significance of the global autocorrelation. This number of permutations provided stable results. The low value of

Moran's I (0.0520) indicates that the assumption of independently distributed residuals is not violated. Subsequently, the spatial distribution of the significant regression residuals was examined. Examining the regression residuals can assist in revealing a pattern of heterogeneity across the impacted area. This knowledge can be subsequently used to improve the model and undertake further hypothesis testing. The mapped residuals and the LISA values were used to reveal a pattern of heterogeneity across the impacted area.

Global Moran's Index	
Low values surrounded by high values (low-high)	*High values surrounded by high values (high-high)*
Low values surrounded by low values (low-low)	*High values surrounded by low values (high-low)*

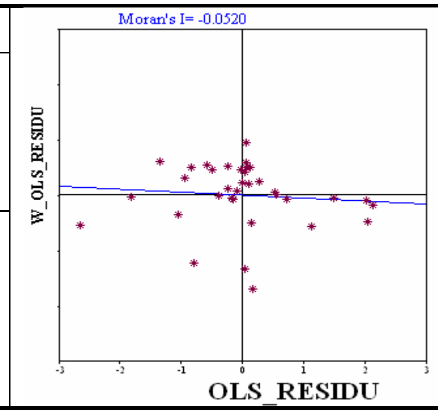

Figure 4.4 Moran Scatter Plot of Residuals (after 999 permutations)

The significance map of the residuals (see Figure 4.5) shows the blocks within the impacted area where the LISA values are significant. The cluster map of the residuals (see Figure 4.6) shows in which of the Moran scatter plot quadrants each significant residual falls. Significant local clustering of like values (i.e., high-high and low-low) are present in two blocks (p-value = 0.05). The OLS model is underestimating the number of individuals below the poverty level in these two blocks. In one block a significant local clustering (p-value = 0.01) of an unlike value (e.g., low-high) is present. The OLS model is over-estimating the number of individuals below the poverty level in this block.

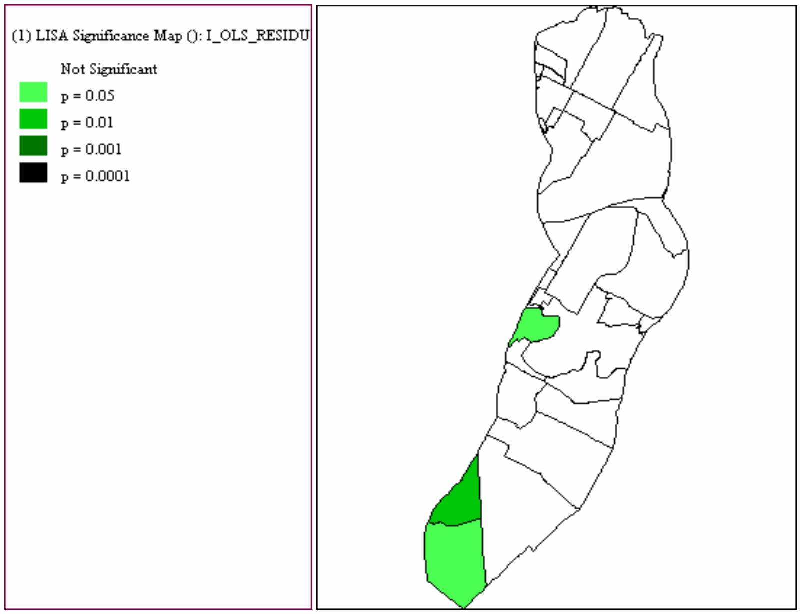

Figure 4.5 LISA Significance Map of Residuals (after 999 permutations)

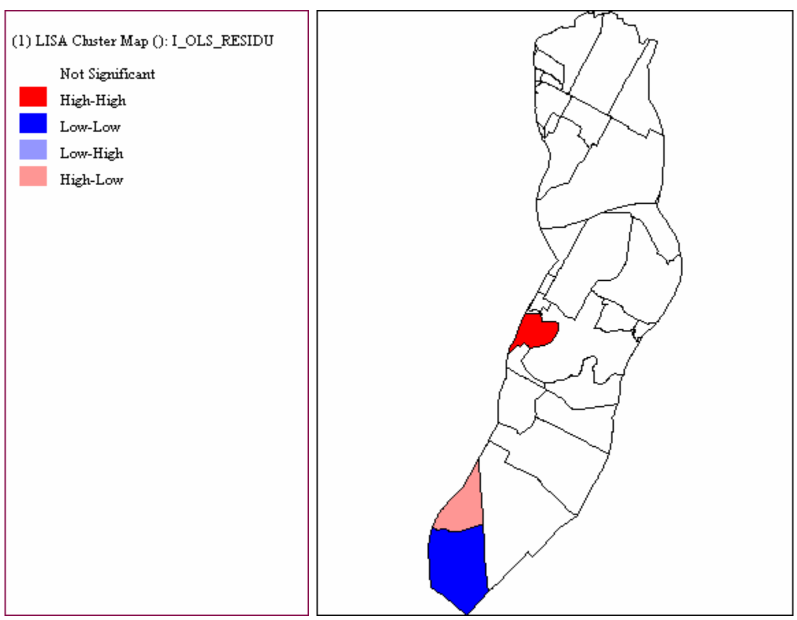

Figure 4.6 LISA Cluster Map of Residuals (after 999 permutations)

Spatial Models

The results of the spatial dependence tests of the "best" OLS model are presented in Table 4.8. Because the Lagrange Multiplier tests for spatial dependence were not highly significant (critical $\chi^2_{0.05,1} = 3.841$), independently distributed observed values and residuals can be assumed. As indicated in the previous section, three blocks within the impacted area, however, showed a cluster pattern. Therefore, the spatial lag and spatial error models were estimated to determine to what extent these models account for the identified spatial pattern.

Table 4.8 Spatial Dependence Test Results

Test	Value	P-value
Robust Lagrange Multiplier (lag)	0.0423686	0.8369188
Robust Lagrange Multiplier (error)	0.1975287	0.656723

Examining the residuals from the spatial error model showed much less correlation globally (see Figure 4.7). The cluster and significant LISA maps (Figures 4.8 and 4.9), however, still revealed clusters of significantly similar residuals.

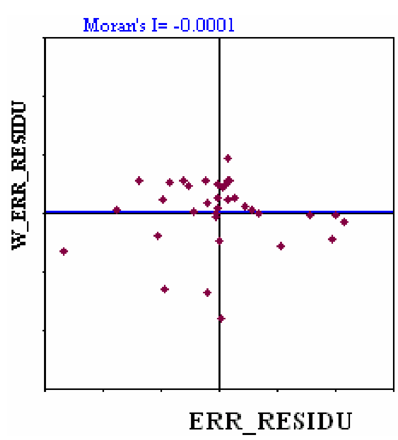

Figure 4.7 Moran Scatter Plot of Error Residuals (after 999 permutations)

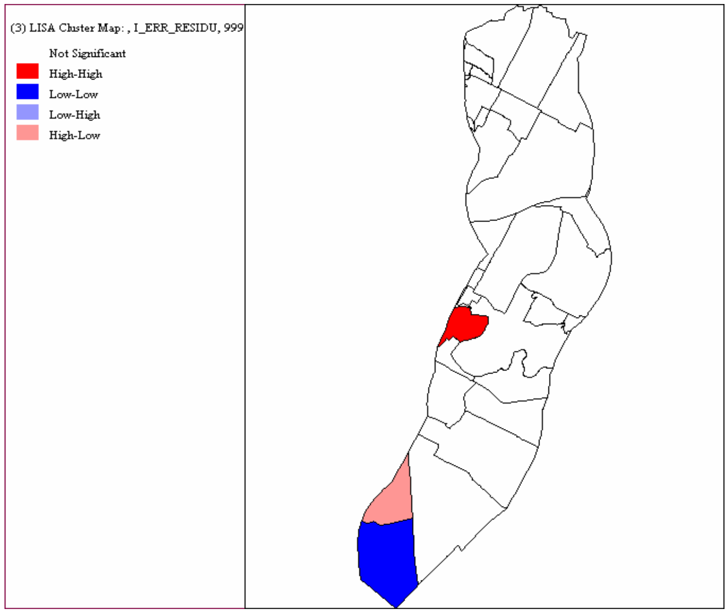

Figure 4.8 LISA Significance Map of Error Residuals (after 999 permutations)

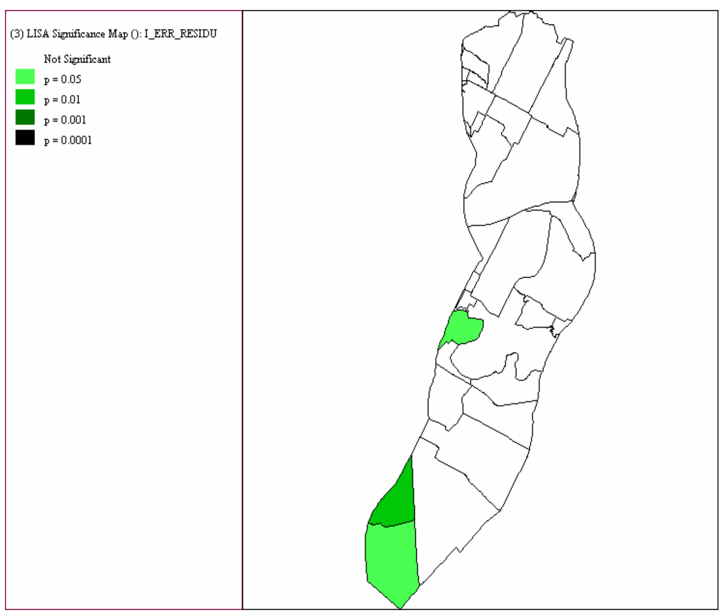

Figure 4.9 LISA Cluster Map of Error Residuals (after 999 permutations)

Table 4.9 contains the estimation results for the "best" OLS, spatial lag, and spatial error models.

Table 4.9 Estimation Results

Variable	"Best" OLS Model		Spatial Lag Model		Spatial Error Model	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
CONSTANT	44.2746	0.1368	47.7929	0.2291	49.4730	0.0538
HH-W-18Y	3.3618	0.0000	3.3777	0.0000	3.3593	0.0000
HH-W-65Y	0.7633	0.1261	0.7577	0.0812	0.7233	0.0886
HHT-OOC	-0.9059	0.000	-0.9081	0.0000	-0.9070	0.0000
HH-F-2	1.4815	0.0295	1.4851	0.0108	1.4053	0.0113
HH-F-3	-3.9525	0.0010	-3.9858	0.0001	-3.8135	0.0000
HH-F-4	-2.6626	0.0007	-2.6722	0.0000	-2.7131	0.0000
WI			-0.0155*	0.9134		
$W\varepsilon$					-0.1339**	0.5611

* ρ
** λ

The key findings from the estimation results can be summarized as follows:

- The difference in the magnitude of the coefficients of the three models is marginal.
- All the coefficients are statistically significant at the 5 percent level, with the exception of the number of households with one or more people over 65 years. In the spatial models, this explanatory variable is statistically significant at the 10 percent level.
- The magnitude and p-values for the ρ and λ coefficients reveal that the spatial context has a relatively insignificant effect on the OLS model specification. Specifically, low-income individuals in neighboring blocks seem to have no effect on the low-income individuals in the block of concern and relevant explanatory variables were not omitted in the OLS specification.
- The residuals of the spatial error model present marginally less correlation than the OLS residuals. Subsequently, the spatial distribution of the target low-income population within the impacted area was mapped using the

estimates from both the "best" OLS and the spatial error models (see following section).

Spatial Distribution of Low-Income Populations

As explained before, the number of low-income individuals was estimated at the block level using both the "best" OLS and spatial error models. Applying the threshold approach, the spatial distribution of target and non-target low-income populations was mapped based on the classic "OLS" model and the spatial model (see Figure 4.10).

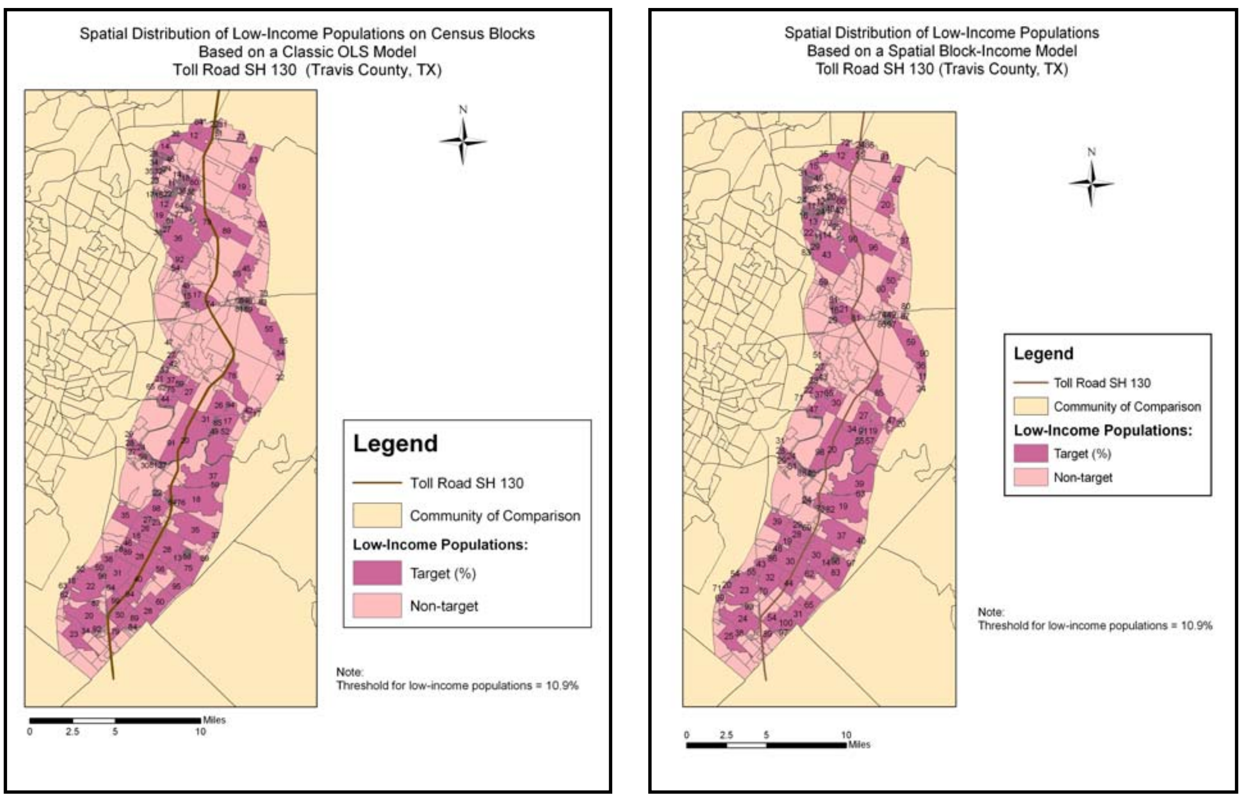

Figure 4.10 Spatial Distribution of Low-Income Population at the Block Level

The following observations can be made after comparing the distribution of low-income populations estimated by the classic OLS model and the spatial model:

- The spatial block-low-income model predicts higher percentages of low-income populations than the "best" OLS model.
- The differences between target and non-target blocks pertain to very small number of geographic blocks.
- In the case of both models, the target low-income population is predicted to reside mostly in the southern portion of the impacted are

4.3.2.5 Conclusions

In general, the classic OLS estimates are sensitive to the model specification and the presence of spatially correlated estimation errors. If observations are not independent, it may result in some coefficients being considered significant when in fact they are not. If there is spatial autocorrelation in the residuals, the model may overestimate or underestimate the observed values. The approach presented in this research therefore demonstrates the importance of assessing the spatial context of observations in an effort to estimate an improved model that accounts for spatial autocorrelation. Spatial econometric models thus extend regression analysis to account for the fact that data used in model estimation often relates to specific geographic areas and therefore may exhibit a certain spatial pattern.

If spatial autocorrelation exists in the data, the OLS parameters are inefficient, and significance tests are unreliable. The spatial models assist in revealing the explanatory variables that are statistically significant after accounting for the spatial autocorrelation. If spatial autocorrelation exists in the residuals due to omitted explanatory variables, it is recommended that the missing variables be identified to explain the spatial pattern in the residuals.

Using the 2000 U.S. Census Data available at the census block group and block levels, the "best" OLS model was estimated at the block group level for the impacted area of a section of the proposed SH 130 toll road in Travis County, Texas. The empirical results disclosed that the regression coefficients are unbiased and statistical significant tests are reliable. The heteroskedasticity and multicollinearity conditions indicated that the estimates of the regression coefficients may fluctuate from one sample to the next. To gauge how much estimation variation or instability was due to collinearity, seven regression equations were estimated using a reduced number of randomly selected observations. The results revealed that instability was not a serious problem. Compared to the "best" OLS, the signs of the parameter estimates did not change, the magnitude of the parameters only changed by 2% or less, and the parameters were statistically significant at the 95 percent confidence level, except the variable that represents households with one or more persons over 65 years which was statistically significant at the 80 or 85 percent confidence levels. Close examination of the OLS residuals revealed that three blocks within the impacted area exhibited a significant cluster pattern. Two spatial models were estimated to improve the understanding of this spatial pattern. The spatial lag and spatial error models confirmed the insignificance of the spatial context of the data (i.e., observations and residuals) for the impacted area. The residuals of the spatial error model, however, presented marginally less correlation than the OLS residuals. The results from the empirical application should, however, not be generalized to other study areas. On the contrary, the existence of a spatial pattern should be examined on a case-by-case basis.

4.3.3 Empirical Results of the Sensitivity Analysis

The sensitivity analysis was conducted for the proposed SH 130 toll road segment that traverses Travis County, Texas (see Figure 4.11). The SH 130 extends approximately

91 miles in length from I-35 at SH-195 north of Georgetown (Williamson County) to I-10 near Seguin (Guadalupe County). Since SH 130 is expected to impact a sizable area adjacent to the road segment, a 6-mile wide buffer along the proposed road alignment defined the impacted area (U.S. Department of Transportation & Texas Department of Transportation, 2001). The impacted area covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural effects (i.e., the potential EJ concerns) associated with the proposed toll road.

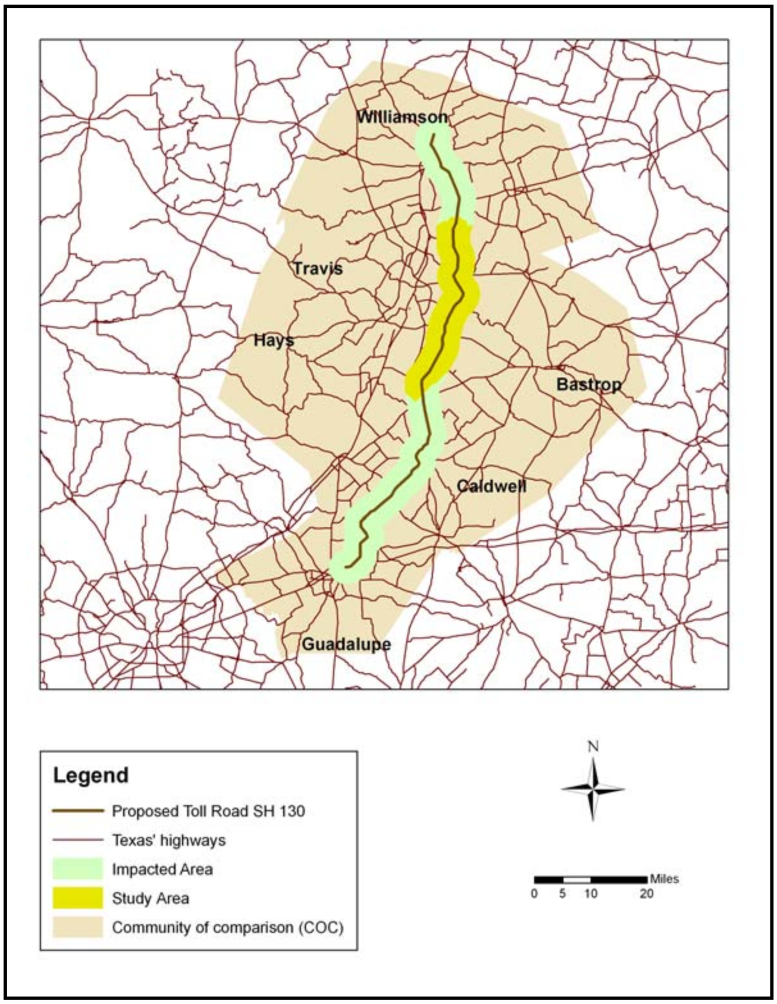

Figure 4.11 Study Area and Community of Comparison

Digital and socio-demographic data for the study area were obtained from the U.S. Census Bureau. Digital files (i.e., "TIGER/LINES") at the tract, block group, block, and TAZ levels were obtained from the ESRI Web site. Custom tables containing the minority and low-income populations for the different geographic scales were obtained from the U.S. Census Bureau's American Factfinder Web site. GIS was used to compile minority populations at the TAZ level. The CTPP 2000 CDs containing Texas data were acquired from the Bureau of Transportation Statistics. To estimate low-income population at the block level, a *block-low-income model* was estimated (see Section 4.3.2.4). Table 4.10 summarizes the data sources used in this analysis.

Table 4.10 Data Sources Used for Sensitivity Analysis

Scale of Geographic Analysis	Data Sources	
	Race	Income
Census Tracts	SF 1	SF 3
Census Block Group	SF 1	SF 3
Census Block	SF 1	*Block-Low-Income Model*
TAZ	SF 1*	CTPP 2000

*Based on data at block level
Source: 2000 U.S. Census Data

For this analysis, the chosen COC consisted of Williamson, Travis, Bastrop, Hays, Caldwell, and Guadalupe counties (see Figure 4.11). GIS was used to compute descriptive statistics for the COC and the pertinent thresholds (see Table 4.11).

Table 4.11 Demographic Characteristics of the Community of Comparison (COC) and Threshold Values

2000 Census Data	Community of Comparison (COC)	Mean	Standard Deviation
Total population	1,338,789	4,868	2,310
Minority population	489,789	1,781	1,351
Population at or above poverty level	1,129,325	4,107	2,181
Population below poverty level (low-income population)	138,151	502	543
Threshold for minority populations	**36.7 %**		
Threshold for low-income populations	**10.9 %**		

4.3.3.1 Spatial Distribution of the Target and Non-Target Population Groups

Figures 4.12 and 4.13 were prepared to illustrate the spatial distribution of the target population groups (i.e., minority/low-income populations) at each geographic scale. When comparing these maps, the following observations can be made:

- The spatial distribution of target minority/low-income populations is sensitive to the scale of geographic analysis used. In other words, the identified areas with target population groups differ from one scale to another. When comparing these maps it is evident that some areas exhibit target population groups at a certain scale (e.g., block group), but not at a more detailed scale (e.g., block). On the other hand, some areas are identified as non-target population areas at a certain scale (e.g., block group) and as target population areas at a more course scale (e.g., tracts). Furthermore, the changes observed in the spatial distribution among different scales (i.e., a course scale vs. a detailed scale and vice versa) do not reveal a specific pattern.
- The chosen scale of geographic analysis effects the spatial concentration of EJ populations. Target populations seem to be more clustered at the aggregated scales (i.e., tracts, block groups, and TAZs) and more dispersed at the disaggregate scale (i.e., blocks).
- When comparing the results for the four geographic scales, it appears that the detailed scale (i.e., block) provides a more complete spatial distribution of the target population groups within the study area. In contrast, the outcome of the course scales (i.e., tracts, block groups, and TAZs) may overlook some EJ population groups that do not align with these levels of aggregation.

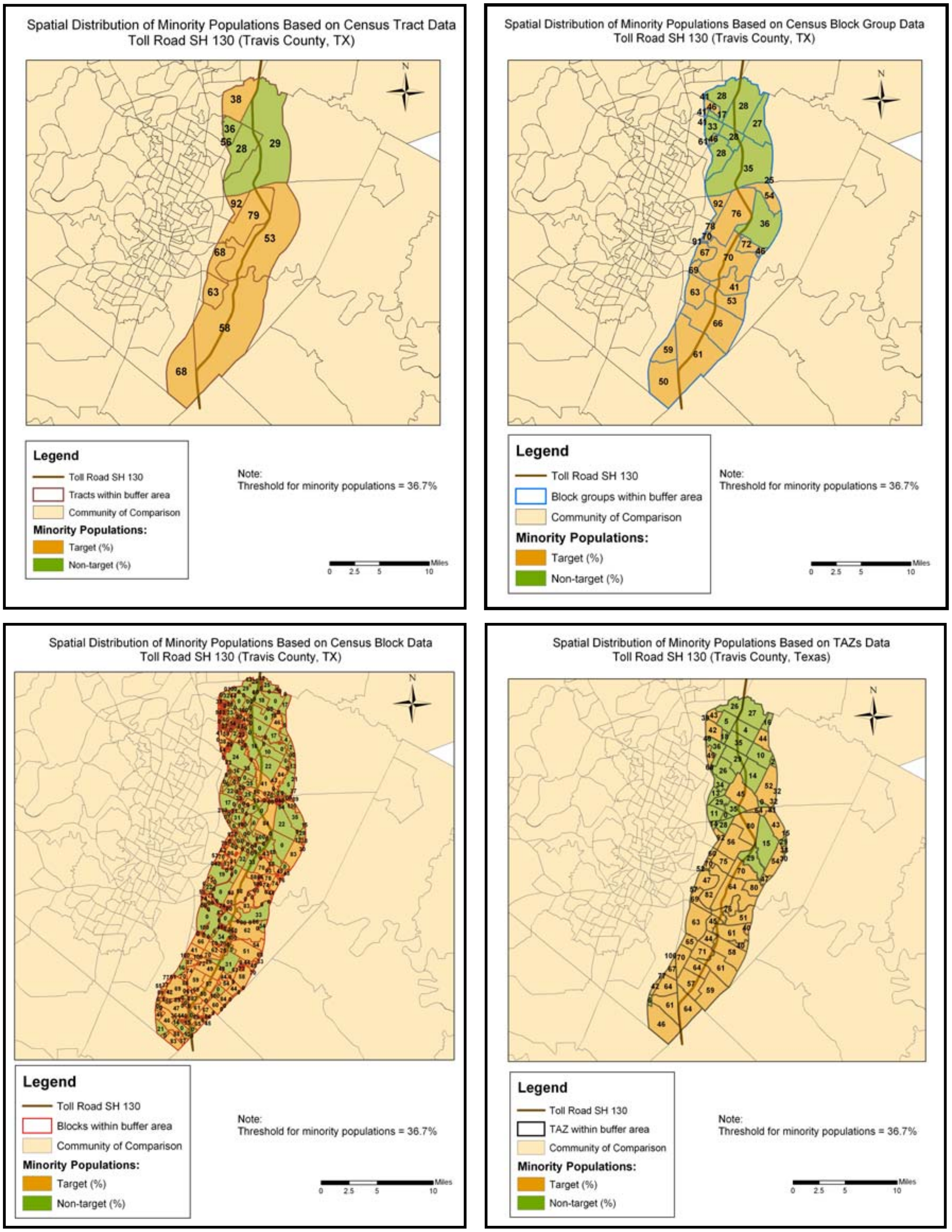

Figure 4.12 Spatial Distribution of Target Minority Populations in the Impacted Area Given Different Geographic Scales

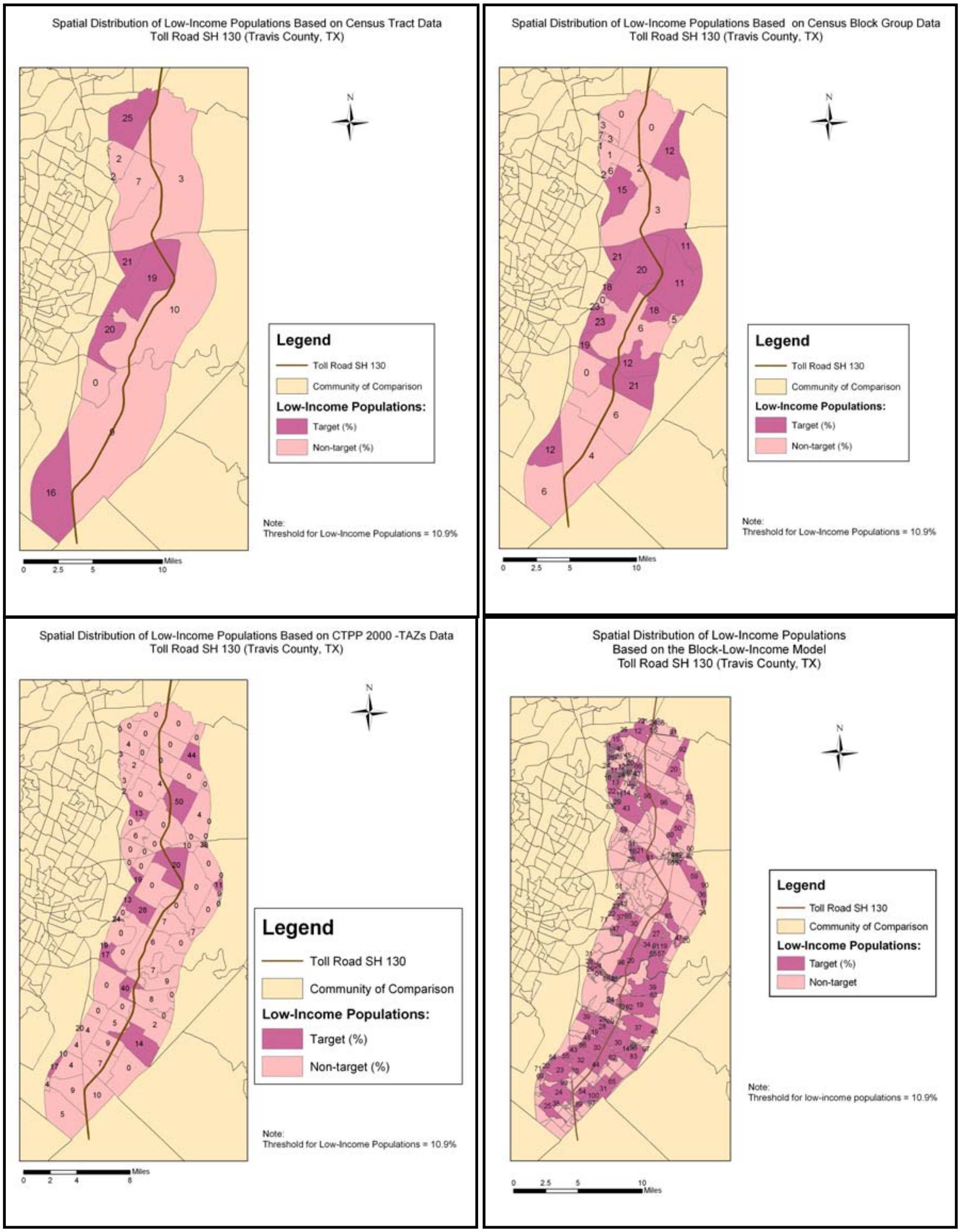

Figure 4.13 Spatial Distribution of Target Low-Income Populations in the Impacted Area Given Different Geographic Scales

4.3.3.2 Statistical Analyses of the EJ Population Groups within the Impacted Area

Using GIS, descriptive statistics for minority and low-income populations in the area impacted by the SH 130 toll road in Travis County, Texas, were calculated at the four scales of geographic analysis (see Tables 4.12 and 4.13, respectively).

Table 4.12 Descriptive Statistics for Total Population and Minority Populations in the Impacted Area in Travis County, TX

Scale of Geographic Analysis	Study Area			
	Units	**Total Population (Inhabitants)**	**Mean**	**Standard Deviation**
Tracts	13	89,702	6,900	3,654
Block groups	35	83,586	2,388	1,463
Blocks	1,084	58,961	54	124
TAZs	80	58,991	737	1,296
Scale of Geographic Analysis	**Units**	**Total Minority (Inhabitants)**	**Mean**	**Standard Deviation**
Tracts	13	47,486 (53%)	3,653	1,736
Block groups	35	42,994 (51%)	1,228	925
Blocks	1,084	28,990 (49%)	27	73
TAZs	80	29,014 (49%)	363	587

Table 4.13 Descriptive Statistics for Total Population and Low-Income Populations in the Impacted Area in Travis County, TX

Scale of Geographic Analysis	Study Area			
	Units	**Total Population (Inhabitants)**	**Mean**	**Standard Deviation**
Tracts	13	68,392	5,261	2,604
Block groups	35	77,257	2,207	1,498
Blocks	1,084	55,709	51	104
TAZs	80	24,199	302	526
Scale of Geographic Analysis	**Units**	**Total Low-Income (Inhabitants)**	**Mean**	**Standard Deviation**
Tracts	13	6,979 (10%)	537	427
Block groups	35	6,049 (8%)	173	208
Blocks	1084	16,876 (30%)	15	28
TAZs	80	1,632 (7%)	20	41

The results from the statistical analysis suggest the following:

- The variability in the statistics for low-income populations in the impacted area given the four geographic scales of analysis may be due to the scale effect (Wrigley, 1995). The scale effect is the tendency to obtain different statistical results from the same data set when the information is grouped at different levels of spatial resolution (i.e., tracts, block groups, blocks, and TAZs). The same is true for the statistics for minority populations in the impacted area, especially at the tract and block group levels.
- The homogeneity test revealed that the proportions of minority and non-minority population groups in the impacted area are not the same for the two courser scales of geographic analysis (i.e., tracts and block groups). The p-value is so minuscule that the null hypothesis can be rejected at any level of significance (α). On the other hand, the proportions of minority and non-minority population groups in the impacted area are the same for the two detailed scales (i.e., blocks and TAZs) at any α. This is expected because minority populations at the TAZ level were computed from block data using GIS. As a result, the scale effect had no influence in the statistic.
- The homogeneity test also suggests that the proportions of low-income and non-low-income population groups in the impacted area are not the same for the four scales of geographic analysis. The p-value is so small that the null hypothesis can be rejected at any α.

4.3.3.3 Statistical Analyses of the Target EJ Population Groups within the Impacted Area

Using GIS, descriptive statistics for the target population groups in the area impacted by the SH 130 toll road in Travis County, Texas, were computed at the four scales of geographic analysis (see Table 4.14).

Table 4.14 Descriptive Statistics for Target Population Groups in the Impacted Area in Travis County, TX

Scale of Geographic Analysis	Target Minority (% Total Minority)	Mean	Standard Deviation
Tracts	41,236 (87%)	4,124	1,677
Block groups	35,124 (82%)	1,405	987
Blocks	24,527 (85%)	57	106
TAZs	23,092 (80%)	453	609
Scale of Geographic Analysis	**Target Low-Income (% Total Low-Income)**	**Mean**	**Standard Deviation**
Tracts	4,578 (66%)	4,124	1,677
Block groups	4,658 (77%)	1,405	987
Blocks	16,475 (98%)	57	106
TAZs	1,045 (64%)	453	609

Statistical comparisons of target population proportions were conducted using census blocks as the basis for comparison. The results suggest the following:

- The variability in the statistics for target minority populations in the impacted area given the four geographic scales of analysis may be due to the scale effect (Wrigley, 1995). The same is true for the statistics for target low-income populations in the impacted area.
- The proportion of target minorities at the block level differs from the proportion of target minorities at the other levels of aggregation. The data clearly shows that the proportion of target minorities at the block level is higher than that at the block group and TAZ levels. The p-value is so minuscule that for any reasonable α, the null hypothesis—no difference

between population proportions—should be rejected. On the other hand, the data strongly suggest that the proportion of target minorities at the block level is lower than that at the tract level. Again, the p-value is so small that for any reasonable α, the null hypothesis should be rejected.

- The proportion of target low-income individuals at the block level differs from the proportion of target low-income individuals at the other levels of aggregation. The data strongly suggest that the proportion of target low-income individuals at the block level is higher than that at the tract, block group, and TAZ levels. The p-value is so minuscule that for any reasonable α, the null hypothesis should be rejected.

4.3.3.4 Correlation between Minority and Low-Income Populations in the Impacted Area

The Spearman's rank correlation coefficient (r_s) was estimated to assess the direction and strength of the relationship between minority and low-income populations in the impacted area for the four geographic scales (see Table 4.15). This nonparametric statistic reveals whether there is a positive, negative or no correlation between these two population groups in the area impacted by the proposed toll road.

Table 4.15 Strength and Direction of the Relationship between EJ Populations in the Study Area

Scale of Geographic Analysis	Units	Spearman's rank correlation coefficient (r_s)	
		EJ Populations	Target EJ Population
Tracts	13	+ 0.666	+ 0.612
Block groups	35	+ 0.373	+ 0.351
TAZs	80	+ 0.570	+ 0.482
Blocks	1,084	+ 0.768	+ 0.716

The results suggest the following:

- There is a positive correlation between minority and low-income populations in the study area for the four geographic scales.
- The strength of the relationship differs from one scale to another. The stronger correlation is provided by the smallest geographic scale (i.e., blocks).
- The geographic scale may hide the strength of the relationship between EJ populations groups. This finding suggests that inferences about the strength of the relationship between minority populations and low-income populations based on aggregate data are vulnerable to the Ecological Fallacy (Robinson, 1950).

4.4 CONCLUDING REMARKS

This research study highlights the content and geographic scales of census data products relevant to EJ analysis and provides guidance regarding the variables included in these products that may be used in the identification of EJ populations. It is, however, evident that income data is not available at the census block level. This research estimates an income model, called the *block-low-income model*, to address this limitation in conducting EJ assessments of toll road projects that require a higher degree of demographic resolution.

The sensitivity analysis of different geographic scales reveals that the conventional approach, which classifies communities into target and non-target populations using threshold values, is sensitive to the geographic scale used (i.e., the scale effect). The spatial distribution of target and non-target minority/low-income populations within the study area thus changed when the scale of geographic analysis (i.e., tracts, block groups, blocks, and Traffic Analysis Zones [TAZs]) changed. The statistics and the strength of the relationship between minority and low-income populations also differ from one scale to another. These outcomes highlight the effects of scale and aggregation known as the Modifiable Areal Unit Problem (MAUP) and the Ecological Fallacy.

When using U.S. Census data to identify EJ communities at the project level, the scale of geographic analysis selected requires special considerations. The analysis showed that the course scale of TAZs used in travel demand modeling might overlook smaller minority/low-income population groups. A more complete spatial distribution of the EJ communities was obtained at the block level and it is therefore considered more appropriate to assess EJ concerns of toll-road projects with differential impacts on the impacted population. A very detailed scale of demographic analysis (i.e., block level) is thus recommended for toll road projects if

- the impacts are not uniformly distributed over the impacted area,
- there is a possibility that smaller low-income and minority communities might be overlooked at more aggregate levels of geographic analysis, and
- the proposed toll project is perceived to be highly controversial.

The results from the sensitivity analysis also revealed the need for an innovative approach to identify the spatial distribution of EJ communities impacted by toll road projects. Since it has been argued that effective EJ analysis should consider all minority/low-income population groups, regardless of their size, this research presents an innovative approach to identify the concentration of EJ individuals in the affected project areas.

Chapter 5 Step 2: Is There a Potential EJ Concern?

This chapter presents the development of the second analysis/quantitative methodological step of the proposed EJ evaluation methodology (EJEM): **Is there a potential EJ concern?** (see Figure 3.1). The chapter includes background information and an innovative approach for identifying EJ communities impacted by a proposed toll road. The approach uses U.S. Census Data, local indicators of spatial autocorrelation (LISA), and Geographic Information Systems (GIS) modeling in vector and raster data structures to categorize minority and low-income communities and to define zones with small, medium, high, and extremely high levels (concentrations) of EJ populations within the impacted area. The mentioned approach is tested using data for the section of the SH 130 toll road that traverses Travis County, Texas. Relevant findings from the empirical application and concluding remarks are presented at the end.

5.1 Is There a Potential Environmental Justice (EJ) concern?

The second step of the EJEM is the identification of EJ communities in the area impacted by the toll road. The Council on Environmental Quality (CEQ) guidelines (1997) states that an EJ community exists if one of the following conditions is present:

- The minority or low-income population exceeds 50 percent in the impacted area.
- The minority or low-income population percentage in the impacted area is "meaningfully greater" than the minority or low-income population in the general population or other appropriate geographic area.
- There is more than one minority or low-income group present and the minority or low-income percentage, as calculated by summing all minority or low-income persons, meets one of the thresholds presented above.

The U.S. Department of Transportation (USDOT) and the Federal Highway Administration (FHWA) require minority populations to be examined separately from low-income populations, but they do not stipulate specific thresholds for distinguishing minority or low-income communities. Although a low-income person is defined as an individual in a household whose median income is at or below the Department of Health and Human Service (HHS) poverty guidelines, [9] FHWA guidelines allow a state or region to adopt a higher income threshold only if it is not selectively implemented. It must also include all persons at or below the HHS poverty guidelines (Federal Highway Administration, 2002b).

Several state Department of Transportations (DOTs) and Metropolitan Planning Organizations (MPOs) have adapted the above-mentioned regulatory guidelines to reflect the local demographic characteristics and cost of living in their states and regions. For example, the EJ analysis of the Bay Area's Metropolitan Plan in California—a region with a high minority population and a much higher cost of living than the national average—identified "communities of concern" as zones with (1) more than 70 percent minority residents or (2) more than 30 percent residents with a household income twice the federal poverty level (ICF Consulting, 2003). The criteria used by 64 MPOs to distinguish minority and low-income communities are summarized in Tables 5.1 and 5.2, respectively (Lederer et al., 2005). Most of these MPOs use a threshold approach to identify EJ communities, comparing the demographics of the impacted area with the

[9] Since the Department of Health and Human Service poverty guidelines are based on the U.S. Census poverty threshold, this is essentially the same definition as the "very low-income" under the National Guidance for Conducting Environmental Justice Analyses (EPA, 1998). The National Guidance defines the "very low-income" population as persons in households below the U.S. Census Bureau's poverty threshold.

demographics of a more general area (referred to as the community of comparison or COC).

Table 5.1 Criteria Used by MPOs to Distinguish Minority Areas

Criteria	MPO respondents (%)	Comment
Percentage of minority persons greater than the average percentage throughout the region*	65	Several MPOs with large minority populations applied a factor of 1.25 or 2.0 to increase the threshold (the average percentage throughout the region).
Percentage of minority persons greater than 50%*	15	CEQ guideline
Percentage of minority persons greater than absolute standards*	16	Some MPOs with large minority populations (that may actually constitute a majority of the population) adopted absolute standards that were as high as 70% and 90%.
Divide the region into minority quartiles and compare the impacts in the various groups	4	---
TOTAL =	100	

*Threshold approach
Source: Lederer et al. (2005)

Table 5.2 Criteria Used by MPOs to Distinguish Low-Income Areas

Criteria	MPO respondents (%)	Comment
Percentage of low-income persons greater than the average percentage throughout the region*	38	Based on HHS poverty guideline
Compare the average income with a specific income level*	25	Specific income level: HHS poverty level multiplied by a factor Average income of the region multiplied by a factor 65% of the statewide median 75% of the MPO median income level 80% of the median county family income 50% of the median household income
Percentage of low-income population greater than 50%*	14	CEQ guideline
Percentage of low-income persons greater than an absolute percentage*	10	20% or 30%
Divide the region into income quartiles and compare the impacts in the various groups	13	---
TOTAL =	100	

*Threshold approach
Source: Lederer et al. (2005)

It is important to emphasize that the use of thresholds for identifying EJ communities is a function of the geographic scale of analysis chosen, the socio-demographic characteristics of the COC, and ultimately the geopolitical unit chosen (e.g., state, county, etc.) for the COC. For example, using the Texas poverty rate as the threshold to identify EJ communities may overlook some EJ communities at the project level. From Table 5.3 it is evident that some of the most populous Texas counties, such as Harris and Dallas, have a lower estimated poverty rate than the state (U.S. Census Bureau, 2005a and 2005b), while several less-densely populated counties, such as Cameron and Hidalgo, have poverty rates almost at or above 35 percent. Using the state as the COC and thus the state poverty rate as the threshold value to identify EJ communities in an impacted area in Harris County, for argument's sake, could potentially overlook a number of low-income communities impacted by a toll road project.

Table 5.3 Texas Poverty Facts (2002)

County	Estimated Poverty Rate (%)	Total Poor (Inhabitants)
Collin	5.2	28,967
Williamson	5.7	16,323
Fort Bend	7.2	28,285
Denton	7.3	34,869
Montgomery	7.4	24,007
Tarrant	11.6	173,307
Galveston	12.8	32,846
Harris	14.6	512,131
Travis	14.8	122,607
Dallas	15.2	341,573
Bexar	15.6	219,384
Nueces	23.1	71,233
El Paso	26.7	182,362
Cameron	34.8	121,577
Hidalgo	36.2	220,153
Texas (Total)	15.6	3.3 million

If notwithstanding the threshold approach is used, it is recommended that the COC specified is only one level more aggregate than the geopolitical unit chosen for developing the demographic profiles of the impacted area.

5.2 Identify the Spatial Concentration of EJ Populations Within the Impacted Area

This research describes/proposes an innovative approach for identifying EJ communities impacted by a toll project. The approach consists of five steps. First, the spatial distribution of minority and low-income populations is estimated at the census block level using U.S. Census Data and a spatial *block-low-income model*. Second, local indicators of spatial autocorrelation (LISA) for minority and low-income populations are computed for each census block within the impacted area. The impacted area covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the proposed investment. Third, based on the spatial cluster patterns within the impacted area, the EJ concentration levels (i.e., for minority and low-income populations, respectively) are conceptualized. These concentration levels and their associated p-values are mapped using vector models. Fourth, using a raster environment, the concentration levels of minority and low-income populations are combined into a single raster model. The outcome is a map in which each cell has a value that represents its concentration level. Finally, these values and specified spatial connectivity criteria are used to define EJ concentration zones. These concentration zones thus consist of a group of cells that shares the same values and meets established connectivity criterion.

5.2.1 Local Measures of Spatial Autocorrelation

The fundamental property of spatially autocorrelated data is that values are not random in space and are thus spatially correlated to each other. For EJ analysis, spatial autocorrelation may be defined as the relationship among the attribute values (i.e., minority/low-income populations) that stems from the geographic arrangement of the features (i.e., census blocks) in which these values occur. The local Moran statistic (*I*) can be used to assess the level of spatial autocorrelation for each census block within the impacted area. This statistic can be calculated as follows:

$$I_i = z_i \sum_i w_{ij} z_j$$

$$\text{since} \quad z_i = \frac{(y_i - \bar{y})}{\delta}$$

where

I_i is the local Moran statistic for block *i*,
w_{ij} is the spatial weight between census blocks *i* and *j*;
z_i and z_j are deviations from the mean for census blocks *i* and *j* respectively,
y_i is the minority/low-income population in the census block *i*,
$\bar{y}$ is the sample mean, and
δ is the standard deviation of y_i.

With the exception of the spatial weight (w_{ij}), all terms can be calculated from the attribute values of the geographic features. To define the spatial relationship among census blocks, a binary connectivity matrix is constructed based on the rook's case. Rook's case refers to the boundary share. In other words, neighboring geographical features have to share a boundary with a length greater than zero. Then, the elements of the spatial weight matrix can be represented as follows:

$$w_{ij} = \begin{cases} 1 & \textit{if census blocks i and j are contiguous}, i \neq j \\ 0 & \textit{otherwise} \end{cases}$$

A high value of *I* indicates a cluster of similar values (can be high or low) while a low value of *I* refers to a cluster of dissimilar values. Since high or low *I* values may occur by chance, these values have to be compared with their expected values and interpreted given their standardized scores. A statistical test to confirm or reject the null hypothesis of no spatial dependence assuming a standard normal distribution was thus conducted (Anselin, 1988). Once the local Moran statistic is derived for each census block, different concentration levels of EJ populations can be identified within the impacted area. Specifically, the Moran scatter plot can be used to reveal cluster patterns within the impacted area by type of spatial autocorrelation (see Figure D.1). The upper right and lower left quadrants of the Moran scatter plot indicate the observations with positive spatial autocorrelation (can be high-high or low-low), while the lower right and upper left quadrants show the observations with negative spatial autocorrelation (can be high-low or low-high). Clusters of high values are labeled as “hot spots” while clusters of low values are labeled as “cold spots.” These spatial cluster patterns are used to map the concentration levels of EJ populations within the impacted area.

Low values surrounded by high values (low-high)	High values surrounded by high values (high-high) ***HOT SPOTS***
Low values surrounded by low values (low-low) ***COLD SPOTS***	High values surrounded by low values (high-low)

Figure 5.1 Moran Scatter Plot

GIS modeling in vector data structures was used to assemble the concentration levels and their significance for both minority and low-income populations within the impacted area.

5.2.2 EJ Concentration Zones

Using a raster environment, the impacted area is first divided into grid squares or cells, each of which has a value that represents the phenomenon of interest. Second, the vector maps are converted into raster maps by assigning to each cell a value that represents its concentration level (see Table 5.4). The cell size used to convert the vector models into raster models was determined by the size of the smallest census block within the impacted area to allow the most detailed level of analysis (i.e., represent the smallest EJ community). Third, the two raster maps—one displaying the concentration levels for minority populations and the other the concentration levels for low-income populations—were combined into a single raster model that represents sixteen different levels of concentrations (see Table 5.5).

Table 5.4 Cell Values Based on Spatial Patterns

Concentration levels	Description	Cell values	
		Minority Population	Low-Income Population
*Small	Cluster of low values ("cold spot")	M_1	I_1
Medium	Scatter of low values surrounded by high values	M_2	I_2
High	Scatter of high values surrounded by low values	M_3	I_3
Extremely high	Cluster of high values ("hot spot")	M_4	I_4

*Include areas with no EJ populations

Table 5.5 Concentration Levels of EJ Populations

Concentration level for minority population	Concentration level for low-income population			
	Small	Medium	High	Extremely high
Small	C_{11}	C_{12}	C_{13}	C_{14}
Medium	C_{21}	C_{22}	C_{23}	C_{24}
High	C_{31}	C_{32}	C_{33}	C_{34}
Extremely high	C_{41}	C_{42}	C_{43}	C_{44}

Note: $C_{11} = M_1 + I_1$, $C_{32} = M_3 + I_2$, and so on

The EJ concentration zones were compiled using the raster outcome map displaying the sixteen possible different concentration levels (i.e., cell values) of EJ populations and specified connectivity criteria. Connectivity refers to the eight nearest neighboring cells that share a boundary greater than zero with the cell of concern. The eight nearest neighbors are the cells that are directly to the right or left, above or below, or are diagonal to the cell of concern. Cells are thus grouped into concentration zones if they have the same value and if they meet the spatial requirement of connectivity specified. The final outcome is a map that illustrates the EJ concentration zones with their corresponding concentration levels.

5.3 EMPIRICAL RESULTS

The approach presented in this paper was tested using information for a section of the SH 130 toll road in Travis County, Texas. Using U.S. Census data and a calibrated spatial *block-low-income model*, the minority and low-income populations were estimated at the census block level. The impacted area consisted of a total of 1,084 census blocks. Descriptive statistics for the minority and low-income populations within the impacted area are provided in Table 5.6.

Table 5.6 Descriptive Statistics for the EJ Population within the Impacted Area (1,084 census blocks)

Total Population (inhabitants)	Mean	Standard Deviation	Total Minority Population (inhabitants)	Mean	Standard Deviation
58,961*	54	124	28,990 (49%)	27	73
Total Population (inhabitants)	Mean	Standard Deviation	Total Low-Income Populations (inhabitants)	Mean	Standard Deviation
55,709**	51	104	16,876 (30%)	15	28

*Based on SF 1
**Based on the block-income model
Note: Approximately 90 percent of the minority population in the impacted area is also low-income.

Using GeoDaTM, a software package for exploratory spatial data analysis (Anselin, 2003b), the local Moran statistic for each census block within the impacted area was estimated. Based on the spatial patterns displayed by the Moran scatter plot (see Figure 5.2) census blocks were categorized by concentration levels (see Table 5.7).

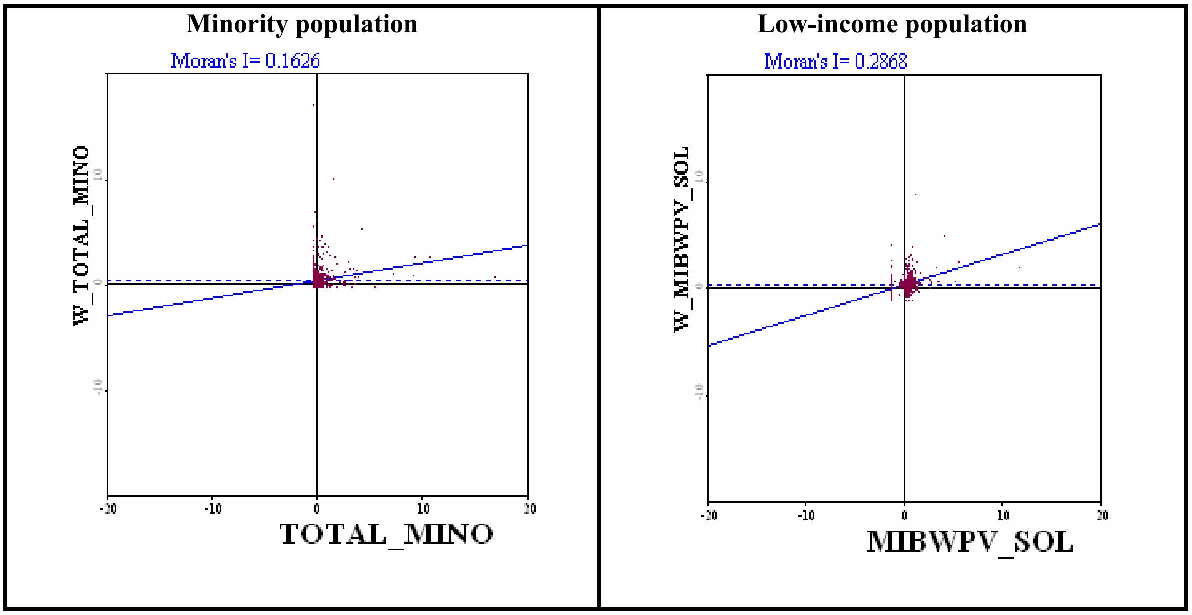

Figure 5.2 Clustering Spatial Patterns for EJ Populations within the Area Impacted by the SH 130 Toll Road in Travis County, Texas

Table 5.7 Cell Values for the Raster Maps Displaying the Spatial Patterns of EJ Populations in the Area Impacted by the SH 130 Toll Road in Travis County, Texas

Concentration levels	Cell values	
	Minority Population	Low-Income Population
*Small	1	10
Medium	2	20
High	3	30
Extremely high	4	40

*Include areas with no EJ populations

The impacted area is subsequently divided into grid squares or cells. The size of the smallest census block determined the cell size used to convert the vector models into raster models. As indicated before, this is to allow the representation of the smallest EJ community.

The vector models were converted into raster models by assigning values representing the EJ concentration levels to each cell (see Table 5.7). Figures 5.3 and 5.4 display the information contained in Table 5.7 graphically. In addition to the concentration levels, the significance levels (p-values) are given.

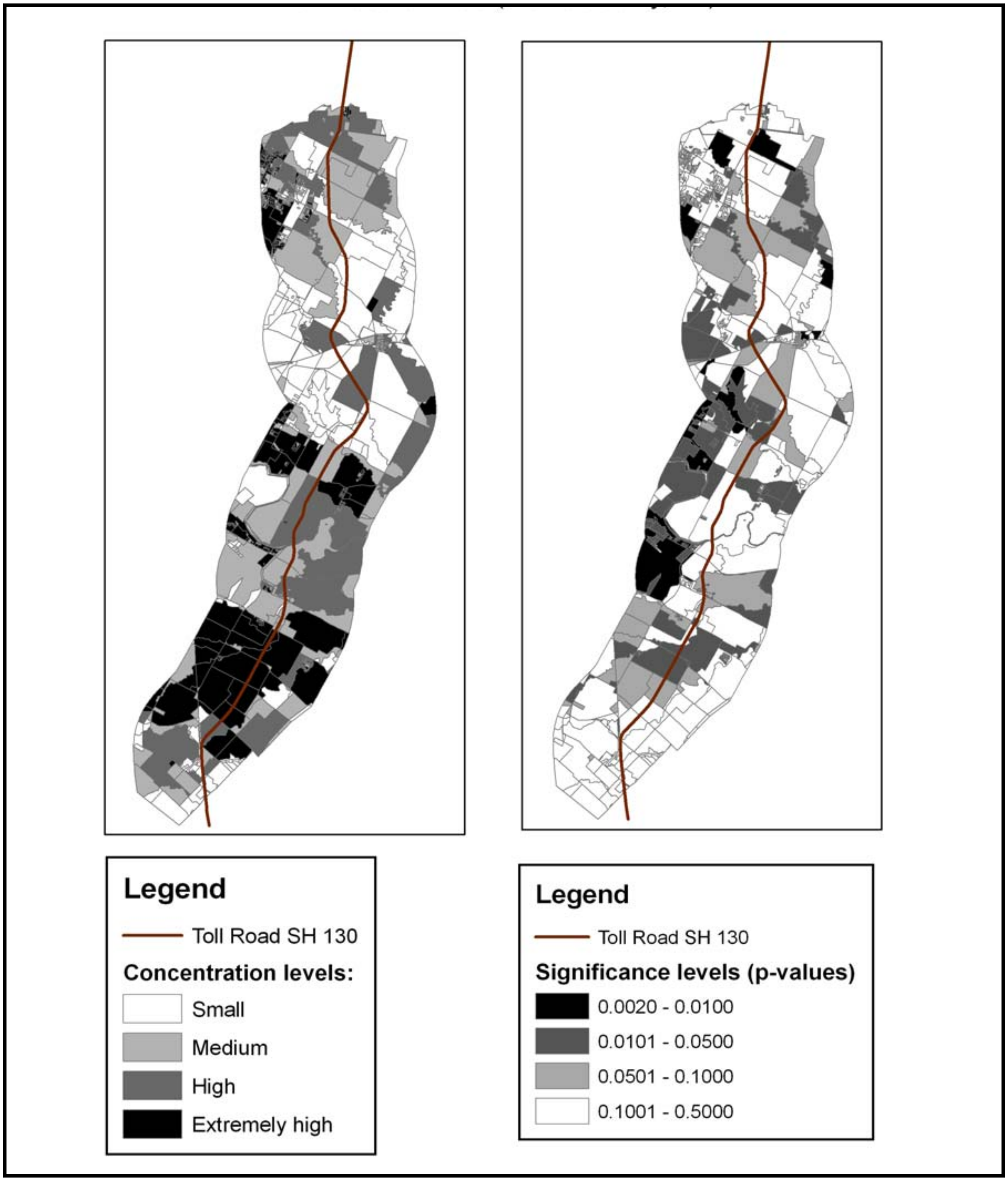

Figure 5.3 Spatial Concentration of Minority Population in the Area Impacted by the SH 130 Toll Road in Travis County, Texas

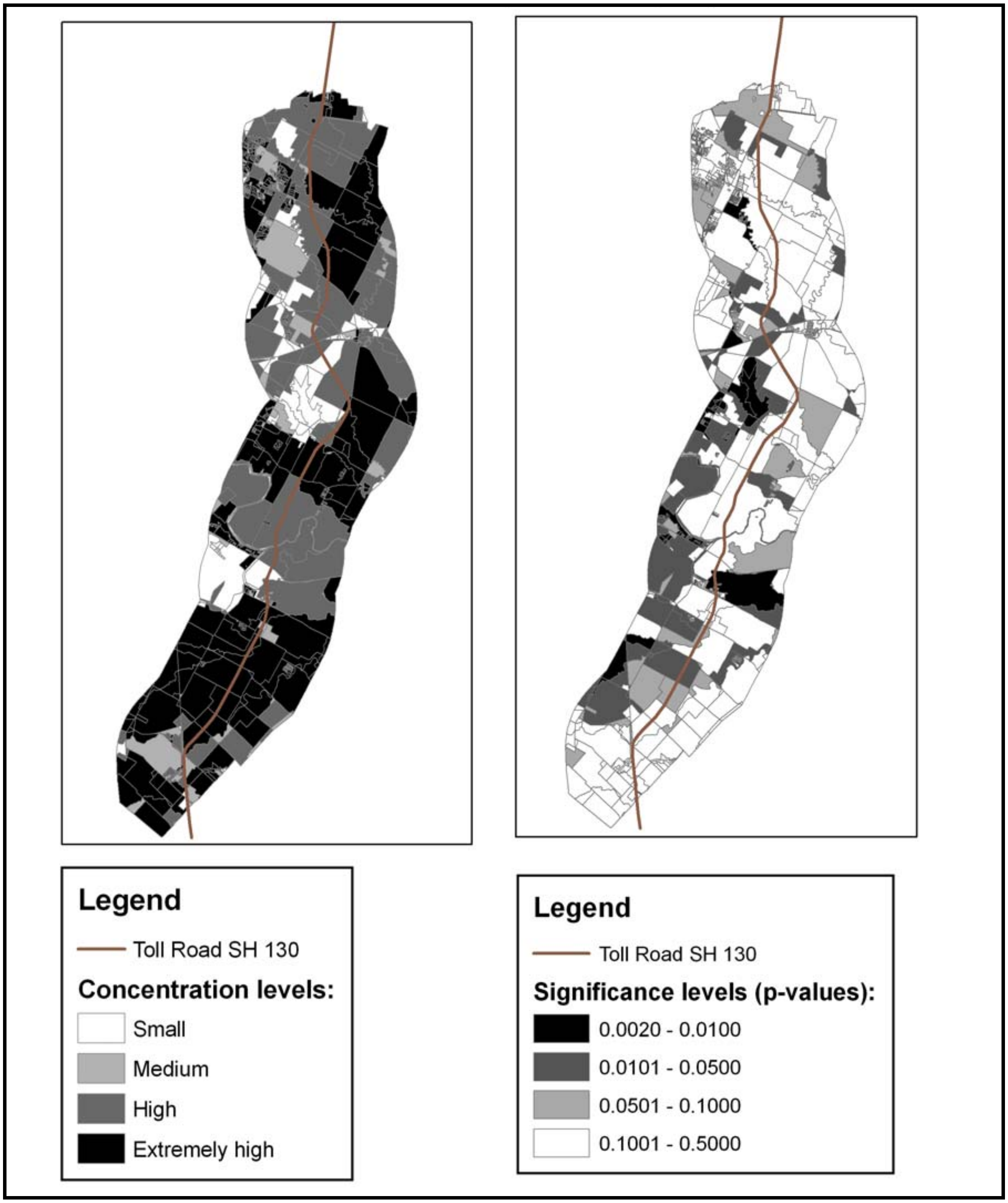

Figure 5.4 Spatial Concentration of Low-Income Population in the Area Impacted by the SH 130 Toll Road in Travis County, Texas

The two raster models were subsequently combined into a single raster reflecting all potential concentration levels of EJ populations within the impacted area (see Table 5.8). Using this new outcome raster and the region group option provided by ArcMap, the EJ concentration zones were defined and their corresponding concentration levels displayed (see Figures 5.5).

Table 5.8 Cell Values for the Outcome Raster Map Displaying the Concentration Levels of EJ Populations in the Area Impacted by the SH 130 Toll Road in Travis County, Texas

Concentration levels for minority population	Concentration levels for low-income population			
	*Small	Medium	High	Extremely high
*Small	11	21	31	41
Medium	12	22	32	42
High	13	23	33	43
Extremely high	14	24	34	44

*Include areas with no EJ populations

To validate the results from the spatial analysis, windshield surveys were conducted in the months of October and November, 2005. These surveys focused on the largest concentration zones (see Figure 5.6). The observed and mapped concentration patterns were consistent.

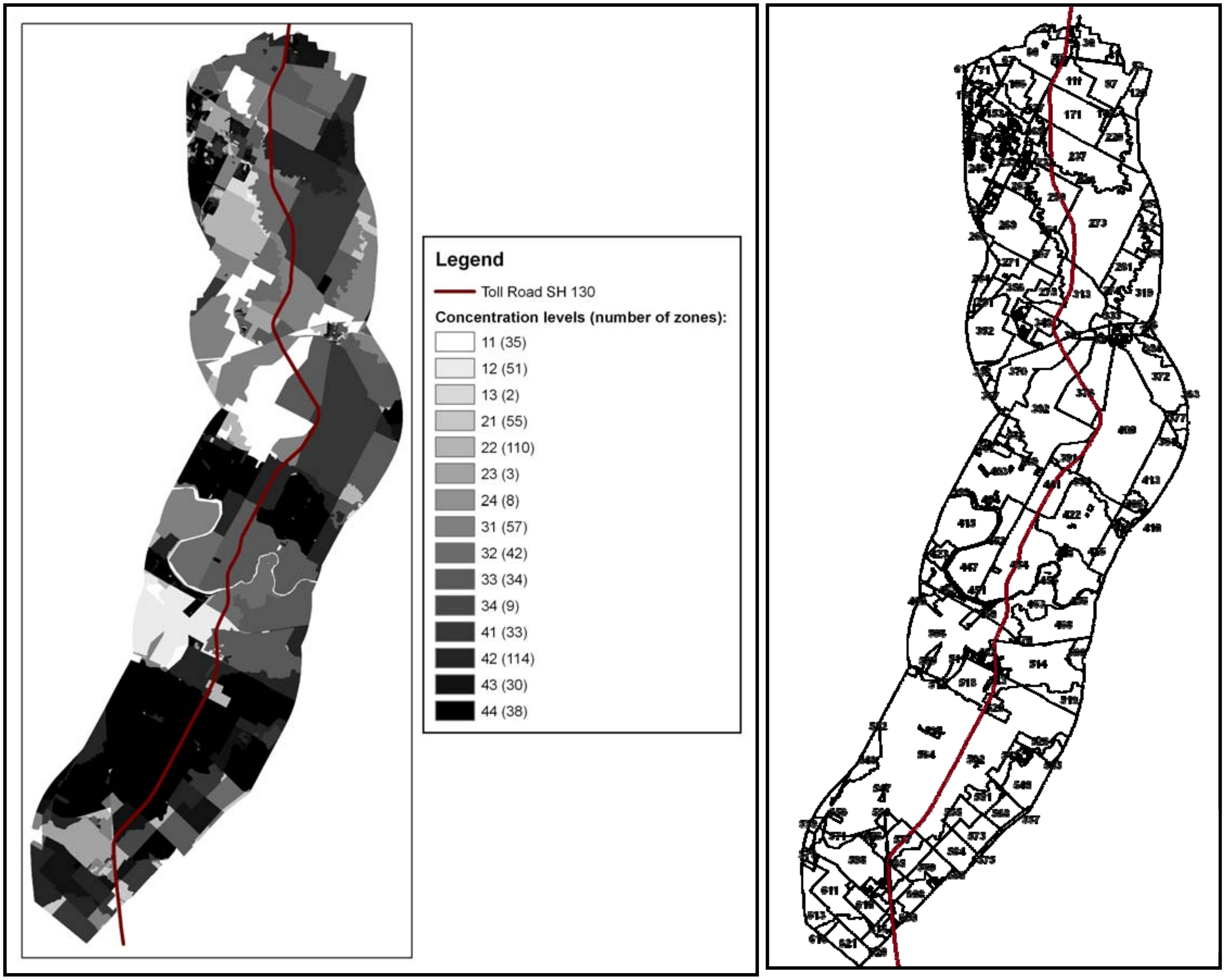

Figure 5.5 EJ Concentration Zones within the Area Impacted by the SH 130 Toll Road in Travis County, Texas (612 EJ Concentration Zones)

Figure 5.6 Neighborhoods in Zones with High Concentrations of EJ Populations

Relevant observations from Figure 5.5 displaying the EJ concentration zones within the impacted area are as follows:

- Each zone, instead of corresponding to a certain geopolitical unit which do not necessarily recognizes the spatial patterns of EJ communities, is homogenous in terms of concentration levels of minority populations and low-income populations. The final outcome map contains 612 zones instead of 1,084 census blocks.

- All concentration levels are present in the impacted area with the exception of concentration level 14 (i.e., extremely high concentration of minority population and low concentration of low-income population). In addition, the presence of clusters of EJ zones with extremely high levels of both minority and low-income populations are particularly noticeable in the south, central-west, and north-west portions of the impacted area.
- The effect of the proposed road on EJ populations within the impacted area can be assessed by overlaying the EJ concentration zones with the anticipated impacts. For example, overlapping the EJ concentration zones layer with layers displaying the potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the toll road will help to determine whether this road would burden EJ populations disproportionately as compared to non-EJ populations.
- The very small EJ concentration zones within the impacted area reveal the presence of small pockets of EJ populations. This outcome map should thus be validated through both visual inspection and the gathering of local demographic data. Agencies that administer federal income sensitive programs, such as food stamps, section 8 housing, and free/reduced price meals, may be valuable sources of information to validate these EJ concentration zones.

5.4 Relevance of EJ Concentration Zones for EJ Assessment

The proposed approach allows the analyst to compile zones displaying different concentration levels of EJ populations as opposed to a generic label of target minority/low-income populations versus non-target minority/low-income populations. Also, the proposed methodology allows for the identification of very small zones containing EJ populations, thereby fulfilling the federal requirement that all minority/low-income populations be considered in EJ analysis, irrespective of the size of the community.

Defining zones as a function of the concentration levels of EJ populations can also help DOTs to focus their community outreach efforts as follows:

- Strategic points for liaising with the community can be identified by overlapping the EJ concentration zones with layers that contain community facilities (e.g., churches, schools, community centers, and shopping). Additional places beyond churches and schools accessible to all in the affected community can thus be identified (see Chapter 9).
- The size and distribution of the EJ concentration zones provide a sense of the scale of the effort required for validating the spatial distribution of EJ communities within the impacted area. Because information for small pockets of minority populations is usually obtained from churches, community centers, and by visual inspection, the validation of small zones may be more time consuming than the larger zones.
- It is foreseen that it would be easier to identify and quantify the impacts on larger zones than on smaller zones. Therefore, care should be taken to ensure the participation of minority and low-income populations living in these small pockets to ultimately enhance the EJ assessment of toll road projects.

- The anticipated impacts on EJ communities can be displayed by overlaying the EJ concentration zones with the anticipated impacts. These map overlays can be very useful in communicating the adverse impacts and the proposed mitigation options to the public. High concentrations of minority and low-income populations require special attention when (a) EJ concerns are identified and assessed, and (b) when mitigation options are designed to lessen or offset the negative impacts.

5.5 Concluding Remarks

This research presents an innovative approach for identifying concentrations of Environmental Justice (EJ) communities impacted by a toll rod project. The approach uses U.S. Census Data, spatial autocorrelation measures at the census block level, and Geographic Information Systems (GIS) modeling in vector and raster data structures to both categorize minority and low-income populations by concentration levels and define zones as a function of EJ concentration levels and established connectivity criteria. Zones with low, medium, high, and extremely high concentrations of EJ populations can thus be defined within the impacted area. Each zone, instead of corresponding to a certain geopolitical unit which do not necessarily recognizes the spatial patterns of EJ communities, is homogenous in terms of concentration levels of minority populations and low-income populations. This approach therefore overcomes some of the limitations of the threshold analysis that divides the community into two groups (i.e., target EJ population and non-target EJ population) and whose results depend on the community of comparison (COC) chosen and the geographic scale of analysis used.

The concentrations of EJ populations within the impacted area can be used for effective EJ analysis. Specifically, the results of the proposed approach can be used to assess who benefits and who is burdened by the potential ecological, mobility, safety, social, and economic impacts associated with the toll road condition relative to the non-toll road condition by overlaying the EJ concentration zones with the anticipated impacts. Although no clear federal guidance exists on what is a disproportionate or adverse impact, obviously if zones with high concentrations of EJ communities incur most of or significantly more of the burdens associated with a transportation project compared to zones with no or low concentrations of EJ communities there is cause for concern. Finally, the outcome map showing the spatial concentration of EJ communities can be used by state Department of Transportations to focus their community outreach efforts. Specifically, this map can help an analyst to (a) identify strategic points within the affected area for liaising with the community, (b) obtain a sense of the scale of the effort required for validating the spatial concentration of EJ communities within the affected area, and (c) communicate the adverse impacts and the proposed mitigation options to the affected EJ communities.

Chapter 6 Step 3: What are the Additional Impacts of Concern Imposed by the Toll Road versus the Non-toll Road?

This chapter presents the third analysis/quantitative methodological step of the proposed EJ evaluation methodology (EJEM): **What are the additional impacts of concern imposed by the toll road versus the non-toll road?** (see Figure 3.1). An in-depth literature review is undertaken regarding the documented EJ concerns pertinent to transportation investments with a special emphasis on tolled facilities. The documented impacts are critically reviewed to identify the potential additional impacts of toll roads relative to non-toll roads on EJ communities. This section of the document includes a detailed *Toll Road Impact Matrix* that may be used by the transportation agency as a reference when identifying the additional benefits and burdens associated with toll roads (alternative 2) as compared to non-toll roads (alternative 1).

6.1 Environmental Justice Concerns Pertinent to Transportation Projects

The impacts pertaining to highway projects have been well documented in the literature. Table 6.1 summarizes the most pertinent impacts associated with highway projects categorized as follows: (1) physical environmental quality effects, (2) mobility and safety effects, (3) socio-economic effects, and (4) cultural effects. These categories relate to aspects of the transportation system and the natural environment that are particularly important to NEPA participants. These impacts are not necessarily negative. For example, a new highway may have a positive or negative impact on air quality, access to jobs, and land and housing property values. In this chapter, this broad list of impacts is examined to determine the potential additional impacts imposed by toll roads.

Ultimately, however, the list of impacts needs to be finalized in consultation with the affected communities. Finally, when conducting EJ analysis, the distribution of the additional benefits and burdens across income and racial groups needs to be critically reviewed.

Table 6.1 Potential Impacts of Highway Projects

Physical Environmental Quality Effects	
Air Quality	Effects of pollutants and air toxics (e.g., public health and land use)
	Regional compliance with Clean Air standards and conformity
	Reduction in single-occupant vehicle (SOV) use
Noise	Effects on sensitive site noise contour levels (e.g., public health and land use)
Water Resources	Effects on surface water quality (e.g., drainage characteristics)
	Effects on ground-water quality
	Effects on flood plains (e.g., flood characteristics)
	Effects on wetlands
Ecosystems	Destruction or disruption of natural resources (e.g., vegetation, wildlife, and threatened and endangered species)
Soil Resources	Effects on prime farmland (e.g., soil contamination)
Hazardous Materials	Influences of existing/abandoned landfill sites
	Influences of known/potential hazardous materials sites
Mobility and Safety Effects	
Highway/Roadway	Effects on travel patterns (e.g., mode choice and route assignment)
	Effects on service (e.g., average travel/delay time and running speed)
	Effects on system capacity (person trips)
	Effects on vehicle occupancy
	Effects on accessibility (e.g., to work, school, and shop)
	Effects on safety
Transit Service	Effects on travel patterns (origin-destination transit patterns, transit routes)
	Effects on service (e.g., service coverage, travel times, service frequency)
	Effects on ridership
Other Forms of Transportation	Effects on bicycle use and safety
	Effects on pedestrian use and safety
Social and Economic Effects	
Neighborhoods	Displacements of residential property
	Effects on neighborhood cohesion, social interaction
	Visual intrusion or obstruction
	Effects on access to work, community facilities, and services
	Effects on access to sensitive sites (e.g., hospitals and schools)
	Effects on recreational places (e.g., parks and water recreational resources)
	Effects on neighborhood traffic patterns
	Effects on land and residential property values
	Pedestrian and bicycle safety
	Cumulative effects on neighborhood quality/safety
Human Health	Bodily impairment, infirmity, illness or death
Local Businesses	Displacements of businesses/public properties
	Effects on employment
	Effects on business access and deliveries
	Effects on land and commercial property values
Economic Development	Changes in available job types
	Changes in property values
	Land use impacts (e.g., effects on services and tax base)
	Delays in the receipt of benefits of DOT programs
Cultural Effects	
Archaeological, Historic and Cultural Resources	Effects on archaeological sites
	Effects on historic sites and landmarks

6.2 What are the Additional Impacts of Concern Imposed by the Toll Road versus the Non-toll Road?

The objective of step 3 of the EJEM is to determine the additional impacts of concern imposed by a toll road (alternative 2) compared to a non-toll road (alternative 1), given the four conceptualized scenarios (see Figure 6.1). The scenarios were conceptualized given the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. An extensive literature review was conducted to determine whether tolling, per se, would exclude low-income and minority individuals from using, and thus sharing in the benefits of, toll roads.

Transportation pricing strategies, irrespective of the objectives—whether to reduce traffic congestion, protect the natural environment, increase transportation revenues, or facilitate the adding of capacity—generally raise equity concerns. For example, congestion pricing allows for the differentiation of tolls charged for traveling during the peak and non-peak hours. Commuters with a high value of time (VOT) are thus more likely to use the tolled facility and benefit from faster trip times than commuters who cannot afford the additional expense. The latter group of commuters may defer trips to off-peak periods, shift to transit, or alter their location choices of home, work, and other activities (Deakin and Pozdena, 1996).

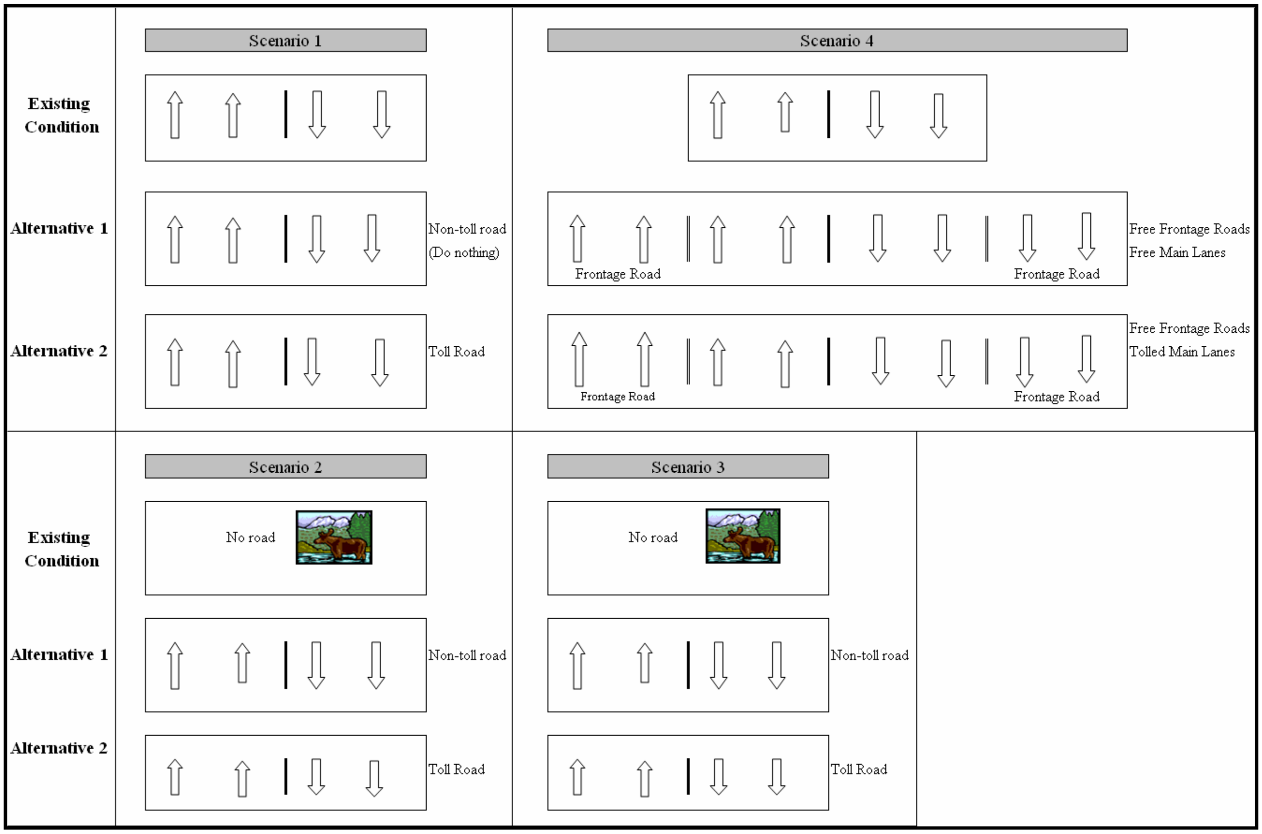

Figure 6.1 Schematic Representation of the Compared Alternatives Given the Four Studied Scenarios

Persad et al. (2004) synthesized the impacts associated with tolled facilities in the U.S. and abroad (see Table 6.2) in a TxDOT technical report entitled "Impacts of Toll Projects and Simplified Methodology for Candidate Evaluation Road." The listed impacts were critically reviewed to identify the potential additional impacts of toll roads relative to non-toll roads on EJ communities.

Table 6.2 Potential Impacts of Toll Roads

Impact	Outcomes
Air quality (pollution)	If traffic is diverted through neighborhoods adjacent to toll roads, then these neighborhoods may experience higher levels of pollution.
Mobility (ability to move between different activity sites measured by average travel speed or time)	Because of significant travel speed improvements, significant time savings accrue to commuters who can afford the toll.
Accessibility (number of opportunities—also called activity sites—accessible within a certain distance, travel time or trip cost)	Toll roads improve the access of upper-income commuters. For lower-income commuters, the extra cost imposed by the toll may present a barrier to accessing services and opportunities.
Route and trip time shifting	Low-income commuters may be forced to change their trip times to avoid congestion on non-toll roads, or low-income shoppers may have to go to other shopping centers to avoid paying a toll.
Safety	Diverted traffic through neighborhoods adjacent to toll roads may pose a higher safety risk to residents, pedestrians, cyclists, and local drivers in these neighborhoods.
Property values and land use	Higher prices of housing units near toll nodes because of increased access to services and opportunities. Industries and businesses that value mobility and reliability tend to locate at nodes and along connectors, which in turn attract high-income developments and leisure businesses.
Social	For low-income individuals, tolls are an additional expense and therefore they may be forced to live and work close to non-toll roads. Since property values tend to be higher at toll road nodes, these areas may become unaffordable for low-income individuals. Toll roads thus have the potential to encourage segregation of population groups by income level.
Economic	Potential positive effects in terms of business relocations, increases in employment, and increased tax revenues.

Source: Adapted from Persad et al. (2004)

6.3 Consult the Toll Road Impact Matrix

The following questions and examples of sub-questions were explored to determine the additional impacts (i.e., benefits and burdens) imposed by toll roads on EJ communities given each of the four toll road scenarios compared to non-toll roads:

- What are the additional physical environmental quality effects?
  - Will the toll road result in a substantial amount of traffic being diverted through an EJ community? If yes, what are the additional air pollution impacts? If yes, what are the additional noise impacts?
- What are the additional mobility and safety effects?
  - Will the toll result in low-income drivers being “priced out” of certain trips?

– What alternative transportation modes are available to those who cannot afford the toll?
– Will EJ individuals be forced to use less desirable modes or routes (to them) to satisfy their mobility needs?
– Are there adequate non-tolled north/south and east/west corridors to serve as alternative roads?
– Will diverted traffic through EJ communities impose a higher safety risk to local pedestrians and cyclists?
– How will the toll road impact transit (e.g., alter bus routes, transit times/schedules?

- What are the additional social and economic effects?
  – Will the non-toll alternatives be equitable in terms of travel time or distance?
  – How will the toll road impact business access for both customers and deliveries?
  – Will the toll road displace a larger number of residents and businesses compared to the non-toll roads?
  – How will the toll road impact (commercial versus residential) property values?
  – How will the toll road impact the access of EJ communities to work, schools, hospitals, and grocery shops?
- What are the additional cultural effects?
  – Will the toll road impact or discourage access to cultural resources (e.g., historic sites, historic landmarks)?

The answers to these and other questions were based on an in-depth literature review of (1) the potential ecological, mobility, safety, social, and economic impacts of highway investments, including priced facilities, and (2) the socio-demographic characteristics of the users of priced facilities. The outcome was a detailed *Toll Road Impact Matrix* (see Table 6.3) that may be used by the transportation agency as a reference when identifying the additional benefits and burdens associated with toll roads (alternative 2) as compared to non-toll roads (alternative 1). The four columns of the matrix represent the four toll road scenarios and the rows represent potential toll project impacts. The entry cells provide examples of the potential additional benefits and burdens associated with the toll road relative to the non-toll road.

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Physical Environmental Quality Effects				
Air Quality				
Pollutants	√ Burdens - Examples: (1) traffic diverted through neighborhoods increases traffic delays resulting in increasing air contaminants in local streets, (2) stop-and-go driving conditions at the toll plaza increase carbon monoxide concentrations, (3) air pollutants increase because travel speed of toll road users is over 55 mph	√ Burdens - Example: (1) stop-and-go driving conditions at the toll plaza increase air pollutants	√ Burdens - Example: (1) stop-and-go driving conditions at the toll plaza increase air pollutants	√ Burdens - Examples: (1) traffic diverted through neighborhoods increases traffic delays resulting in increasing air contaminants in local streets, (2) stop-and-go driving conditions at the toll plaza increase carbon monoxide concentrations, (3) air pollutants increase because travel speed of toll road users is over 55 mph
	√ Benefits - Example: (1) if toll roads have lower traffic volumes and less congestion compared to non-toll roads, then the air contaminants from the former are expected to be less than those from the latter	√ Fewer Benefits - Examples: (1) if toll roads have lower traffic volumes and less congestion compared to non-toll roads, then air contaminants from the former are expected to be less than those from the latter, (2) toll roads attract less traffic than non-toll roads from neighborhood streets, resulting in lower pollution levels	√ Fewer Benefits - Examples: (1) if toll roads have lower traffic volumes and less congestion compared to non-toll roads, then air contaminants from the former are expected to be less than those from the latter, (2) toll roads attract less traffic than non-toll roads from neighborhood streets, resulting in lower pollution levels	√ Benefits - Examples: (1) the added capacity results in less congestion, which leads to fewer air contaminants. However, as demand increase, congestion on frontage roads will reduce this benefit.

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)

Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Regional compliance with clean air standards and conformity	√ Burdens - Example (1) to avoid the extra cost of the toll, traffic diverts to other freeways, corridors, and arterials, thus increasing traffic delays which also causes air pollution at the regional level to increase	√ Fewer Benefits - Example: (1) because toll roads attract less traffic than non-toll roads, the former provides fewer benefits in terms of pollutant reduction at the regional level than does the latter	√ Fewer Benefits - Example: (1) because toll roads attract less traffic than non-toll roads, the former provides fewer benefits in terms of pollutant reduction at the regional level than does the latter	√ Burdens – Example (1) Diversion of traffic to frontage roads will increase stop and go traffic (due to signalization) and thus pollution compared to existing non-toll road.
Reduction in Single-Occupant Vehicle (SOV) use	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Effects	Converting existing non-toll roads into toll roads	Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Noise				
Sensitive site noise contour levels	√ Burdens - Examples: (1) heavy vehicles diverted onto local streets increase neighborhood noise levels, (2) if the additional right-of-way for the toll plaza reduces the distance between sources (e.g., car, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at the receivers increases, (3) high speed limits on toll roads increase traffic noise levels which negatively impact sensitive sites (e.g., hospitals) adjacent to the facility	√ Burdens - Examples: (1) if additional right-of-way for the toll plaza reduces the distance between sources (e.g., cars, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at receivers increases, (2) high speed limits on toll roads increase traffic noise levels which negatively impact sensitive sites (e.g., hospitals) adjacent to the facility	√ Burdens - Examples: (1) if additional right-of-way for the toll plaza reduces the distance between sources (e.g., cars, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at receivers increases, (2) high speed limits on toll roads increase traffic noise levels which negatively impact sensitive sites (e.g., hospitals) adjacent to the facility	√ Burdens - Examples: (1) if additional right-of-way for the toll plaza reduces the distance between sources (e.g., cars, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at receivers increases, (2) high speed limits on toll roads increase traffic noise levels which negatively impact sensitive sites (e.g., hospitals) adjacent to the facility
	√ Benefits - Example: (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes	√ Benefits - Example: (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes	√ Benefits - Example (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes	√ Benefits - Example: (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Water Resources				
Surface water quality	√ Burdens - Examples: (1) traffic diverted through neighborhood contributes to increased levels of water runoff pollution on local streets, (2) spillage of material transported by heavy vehicles that are diverted through local streets contaminates surface water, (3) impervious surfaces created by construction of toll plazas contaminate surface water	√ Burdens - Example: (1) impervious surfaces created by construction of toll plazas contaminates surface water	√ Burdens - Example: (1) impervious surfaces created by construction of toll plazas contaminates surface water	√ Burdens - Example: (1) impervious surfaces created by construction of toll plazas contaminates surface water
	√ No additional benefits	√ No additional benefits	√ No additional benefits	√ No additional benefits
Ground water quality	√ No additional benefits/burdens	No additional benefits/burdens	No additional benefits/burdens	√ No additional benefits/burdens
Flood plains	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Wetlands	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
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	Converting existing non-toll roads into toll roads	Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Ecosystems				
Vegetation	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Wildlife	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Threatened and endangered species	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Soils Resources				
Direct effects on prime farmland	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Hazardous Materials				
Influences of existing/abandoned landfill sites	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Influences of known/potential hazardous materials sites	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens

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Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Mobility and Safety Effects				
Highway/Roadway				
Travel patterns (origin-destination pairs, mode choice, route assignment)	√ Burdens - Examples: (1) lower-income drivers are "priced out" of making certain trips because of the extra toll cost, (2) to reduce trip cost, people are forced to use less desirable (to the user) modes (public transportation, bicycling, walking), (3) drivers are forced to use congested non-toll roads because they cannot afford the toll, (4) people change where they go to shop because the route is tolled, (5) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design	√ No additional burdens	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact travel patterns of adjacent EJ communities, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact travel patterns of adjacent EJ communities, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design
	√ Benefits - Examples: (1) drivers that must be punctual at work and in picking up children from day care use toll roads to bypass congestion, (2) toll roads encourage mode shifts if tolling is coupled with improvements to competing transportation modes	√ Fewer Benefits - Example: (1) lower-income drivers are "priced out" of making certain trips because of the extra cost of the toll	√ Fewer Benefits - Example: (1) lower-income drivers are "priced out" of making certain trips because of the extra cost of the toll	√ Benefits - Example: (1) drivers that must be punctual at work and in picking up their children from day care, use toll roads to bypass congestion

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Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Effects on Service (e.g., average travel/delay time, running speed, trip length, traffic levels of service, queue lengths and duration)	√ Burdens - Examples: (1) travel time of non-toll road users increases because of the "congestion spillover" caused by non-toll routes, (2) drivers have to travel longer distances because of controlled toll road access	√ No additional burdens	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact service to adjacent EJ communities, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design	√ Burdens - Example: (1) congestion at the entrance and exit points of the frontage roads reduces the traffic benefits of the added capacity, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design
	√ Benefits - Examples: (1) travel speeds for toll road users improve compared to when the road was not tolled, (2) drivers are willing to pay the toll to save travel time	√ Fewer Benefits - Examples: (1) because toll roads almost always have better travel speeds than non-toll roads, travel times from the former are expected to be better than those from the latter, (2) drivers have to travel longer distances because of controlled toll road access	√ Fewer Benefits - Examples: (1) because toll roads almost always have better travel speeds than non-toll roads, travel times from the former are expected to be better than those from the latter, (2) drivers have to travel longer distances because of the toll road access control	√ Fewer Benefits - Examples: (1) travel speeds for toll road users improve compared to when the road was not tolled, (2) frontage road users have better travel speeds because of the added capacity initially
System capacity (person trips)	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)

Effects	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Converting existing non-toll roads into toll roads	Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	Converting existing non-toll roads into toll roads but adding adjacent frontage roads as “free alternate” routes
Vehicle occupancy	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged
Accessibility (Refers to the number and types of destinations available to the population. It is usually measured as the number of destinations by type that can be reached within a designated travel time or trip cost)	√ Burdens - Examples: (1) lower-income drivers are "priced out" of making shopping or recreational trips because of the extra cost of the toll, (2) commuters are forced to pay the toll because their workplaces are not accessible by other transportation modes, (3) toll road impacts business access for both customers and deliveries	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact access	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact access	√ No additional burdens
	√ Benefit - Example: (1) Because toll roads almost always improve access to destinations, drivers who can afford the toll improve their accessibility to workplaces, educational centers, health care services, and shopping centers within a specific time budget	√ Fewer Benefits - Example: (1) Because toll roads almost always improve access to destinations, drivers who cannot afford the toll receive fewer benefits from tolled facilities	√ Fewer Benefits - Example: (1) Because toll roads almost always improve access to destinations, drivers who cannot afford the toll receive fewer benefits from tolled facilities	√ Benefit - Example: (1) Because toll roads almost always improve access to destinations, drivers who can afford the toll improve their accessibility to workplaces, educational centers, health care services, and shopping centers within at specific time budget

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Effects	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Converting existing non-toll roads into toll roads	Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Safety	√ Burdens - Example: (1) vehicle/bike/pedestrian accident risk on local streets increases because of the diverted traffic through neighborhoods, (2) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents	√ Burdens - Example: (1) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents	√ Burdens - Example: (1) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents	√ Burdens - Example: (1) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents
	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Transit Service Effects				
Service (i.e., service coverage, travel times, hours and frequency of service, transfers, reliability, comfort, costs)	√ Burdens - Examples: (1) toll road access control results in both longer transit routes and higher transit travel times, (2) bus comfort declines because of increased ridership from travelers who cannot afford the toll, (3) "congestion spillover" increases transit travel times on non-toll roads, (4) transit fares of bus routes using the toll increase to account for the extra cost of the toll	√ Burdens - Example: (1) toll road access control results in both longer transit routes and higher transit travel times, (2) transit fares of bus routes using the toll road increase to account for the extra cost of the toll	√ Burdens - Example: (1) toll road access control results in both longer transit routes and higher transit travel times, (2) transit fares of bus routes using the toll road increase to account for the extra cost of the toll	√ Burdens - Example: (1) congestion on frontage roads increases transit travel times
	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times
Ridership	√ Benefit - Example: (1) toll roads encourage the use of transit service among people who cannot afford the toll	√ Benefits - Example: (1) toll roads encourage the use of transit service among people who cannot afford the toll	√ Benefits - Example: (1) toll roads encourage the use of transit service among people who cannot afford the toll	√ No additional benefits/burdens

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Other Forms of Transportation Effects				
Bicycle use	√ Burdens - Example: (1) vehicle/bicycle accident risks on local streets increase because of the diverted traffic through neighborhoods	√ No additional burdens	√ No additional burdens	√ No additional benefits/burdens
	√ Benefit - Example (1) travelers who cannot afford the toll may become bicycle users	√ Benefits - Example (1) travelers who cannot afford the toll may become bicycle users	√ Benefits - Example (1) travelers who cannot afford the toll may become bicycle users	
Pedestrian use	√ Burdens - Example: (1) vehicle/pedestrian accident risks on local streets increase due to the diverted traffic through neighborhoods	√ No additional burdens	√ No additional burdens	√ No additional benefits/burdens
	√ Benefit - Example (1) walking may increase because people who cannot afford the toll use pedestrian facilities to gain access to bus stops	√ Benefit - Example (1) walking may increase because people who cannot afford the toll use pedestrian facilities to gain access to bus stops	√ Benefit - Example (1) walking may increase because people who cannot afford the toll use pedestrian facilities to gain access to bus stops	

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Social & Economic Effects				
Neighborhood Effects				
Displacement of residential properties	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work

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Neighborhood cohesion, social interaction	√ Burdens - Examples: (1) residents may be "priced out" of certain social trips because of the higher toll costs, (2) toll access control separates members of the community because of longer travel distances, (3) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion	√ Burdens - Example: (1) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion	√ Burdens - Example: (1) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion	√ Burdens - Example: (1) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion
	√ No additional benefits	√ No additional benefits	√ No additional benefits	√ No additional benefits
Visual intrusion or obstruction	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza

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Access* to work	√ Burdens - Example: (1) access to work decreases for those who cannot afford the toll and are therefore forced to travel on congested alternative routes to their workplaces	√ Fewer Benefits - Example: (1) toll roads provide less access to work than non-toll roads if drivers spend more time to get to their workplaces	√ Fewer Benefits - Example: (1) toll roads provide less access to work than non-toll roads if drivers spend more time to get to their workplaces	Burdens - Example: (1) access to work decreases for those who cannot afford the toll and are therefore forced to use the frontage roads, resulting in, their spending more time to get to their workplaces
	√ Benefits - Example: (1) access to work improves for those who can afford the toll and therefore get to work in a shorter period of time than before, when the road was not tolled	√ Benefits - Example: (1) access to work improves for those who can afford the toll if job opportunities increase within a certain travel time budget	√ Benefits - Example: (1) access to work improves for those who can afford the toll if job opportunities increase within a certain travel time budget	√ Benefits - Example: (1) access to work improves for those who can afford the toll and therefore get to work in a shorter time than before, when the road was not tolled
Access* to sensitive sites (health care centers and educational facilities)	√ Burdens - Examples: (1) toll road access control results in longer travel distances to access hospitals, (2) students have to use less desirable transit modes to access community colleges, (3) community members may be "priced out" of certain trips, for example to public libraries	√ Fewer Benefits - Example: (1) toll roads provide less access to educational facilities than non-toll roads if those who cannot afford the toll spend more time getting to school	√ Fewer Benefits - Example: (1) toll roads provide less access to educational facilities than non-toll roads if those who cannot afford the toll spend more time getting to school	√ Fewer Benefits - Example: (1) toll roads provide less access to educational facilities than non-toll roads if those who cannot afford the toll spend more time getting to school
	√ Benefits - Example: (1) toll roads provide more access to health care centers than non-toll roads for drivers who can afford the toll, if they can access more physician clinics within a certain travel time	√ Benefits - Example: (1) toll roads provide more access to health care centers than non-toll roads for drivers who can afford the toll, if they can access more physician clinics within a certain travel time	√ Benefits - Example: (1) toll roads provide more access to health care centers than non-toll roads for drivers who can afford the toll, if they can access more physician clinics within a certain travel time	√ Benefits - Example: (1) toll roads provide more access to health care centers for drivers who can afford the toll, if they can access more physician clinics within a certain travel time

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Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Access* to recreational places (parks, rivers, swimming pools, tennis courts, etc.)	√ Burdens - Example: (1) toll road access control results in longer travel distances to recreational places	√ No additional burdens	√ No additional burdens	√ No additional burdens
	√ Benefits - Example: (1) access to recreational places improves for those who can afford the toll, if they can access more parks within a certain travel time budget	√ Benefits - Example: (1) toll roads provide better access to recreational places than non-toll roads if drivers who can afford the toll, can access more recreational places within a certain travel time budget	√ Benefits - Example: (1) toll roads provide better access to recreational places than non-toll roads if drivers who can afford the toll, can access more recreational places within a certain travel time budget	√ Benefits - Example: (1) toll roads provide better access to recreational places than non-toll roads if drivers who can afford the toll, can access more recreational places within a certain travel time budget
Neighborhood traffic patterns	√ Burdens - Example: (1) traffic volume increases on local streets due to diverted traffic, (2) access to business might change	√ Fewer Benefits - Example: (1) toll roads provide less traffic relief from neighborhood streets than non-toll roads	√ Fewer Benefits - Example: (1) toll roads provide less traffic relief from neighborhood streets than non-toll roads	√ No additional benefits/burdens

***Accessibility is defined as the number of opportunities - also called activity sites - accessible within a certain distance, travel time or trip cost**

Table 6.3 ***Toll Road Impact Matrix*** **(Additional Benefits and Burdens Imposed by Toll Roads on Communities)**				
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Land and residential property values	√ Burdens - Examples: (1) property market values decrease because the diverted traffic onto local streets increases air pollution and traffic noise in neighborhoods, (2) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes	√ Burdens - Examples: (1) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes	√ Burdens - Examples: (1) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes	√ Burdens - Examples: (1) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes
	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility
Pedestrian and bicycle safety	√ Burdens - Examples: (1) changes in traffic patterns on local streets can transform a pedestrian-safe environment into one in which pedestrians are at a greater risk of injury, (2) changes in traffic patterns on local streets can transform a bicycle-safe environment into one in which bicycle users are at a greater risk of injury	√ Fewer Benefits - Example: (1) nearly all toll roads attract less traffic than non-toll roads from neighborhood streets, thus resulting in potentially fewer pedestrian and bicycle safety benefits	√ Fewer Benefits - Example: (1) nearly all toll roads attract less traffic than non-toll roads from neighborhood streets, thus resulting in potentially fewer pedestrian and bicycle safety benefits	√ No additional benefits/burdens

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
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Neighborhood quality/safety	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services
Local Business Effects				
Displacement of businesses/public properties	√ Burdens - Example: (1) local businesses have to close because toll access control may decrease business access	√ Benefits - Example: (1) local businesses can prevail if toll roads keep "big box" stores out of market	√ Benefits - Example: (1) local businesses can prevail if toll roads keep "big box" stores out of market, (2) local businesses have to close if toll access control decrease business access,	√ No additional burdens

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)s				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Local employment	√ Burdens - Examples: (1) employment decreases if local businesses have to close because toll road limits access to clients, (2) employment decreases if local businesses have to scale down operations because toll road limits access to clients	√ No additional burdens	√ No additional burdens	√ No additional burdens
	√ Benefits - Examples: (1) employment increases if diverted traffic results in new customers and the expansion of neighborhood businesses, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide fast and reliable access compared to non-toll roads	√ Benefits - Examples: (1) local employment increases because new businesses open at toll road nodes, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide fast and reliable access compared to non-toll roads	√ Benefits - Examples: (1) local employment increases because new businesses open at toll road nodes, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide fast and reliable access compared to non-toll roads	√ Benefits - Examples: (1) employment at businesses on frontage roads increases because the toll road provides them with better access and exposure, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide them with fast and reliable access
Business access and deliveries	√ Burdens - Examples: (1) toll road access control may increase cost of deliveries, (2) customers have to pay tolls to shop at businesses	√ Fewer Benefits - Example: (1) access to businesses is reduced on toll roads compared to non-toll roads because of toll road access control	√ Fewer Benefits - Example: (1) access to businesses is reduced on toll roads compared to non-toll roads because of toll road access control	√ Benefits - Example: (1) businesses on frontage roads scale up operations because of increased access and exposure resulting from increased traffic on frontage roads

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)

Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Land and commercial property values	√ Benefits - Examples: (1) traffic volumes on local streets may increase exposure of local businesses, and as a result, the market value of these properties may increase, (2) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Examples: (1) market value of commercial properties may increase because frontage roads provide better access and exposure, (2) property values increases if toll road nodes attract "upscale" developments and leisure businesses
Economic Development Effects				
Job creation	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the conversion and operation of the toll road	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the operation of the toll road	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the conversion and operation of the toll road	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the conversion and operation of the toll road, (3) local businesses expand because frontage roads provide them with better access and exposure because of increased traffic on frontage roads

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Changes in available job types	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access
Changes in property values	√ Burdens - Examples: (1) property market values decrease because the diverted traffic onto local streets increases air pollution and traffic noise in neighborhoods, (2) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space	√ Burdens - Example: (1) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space	√ Burdens - Example: (1) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space	√ Burdens - Example: (1) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space
	√ Benefits - Examples: (1) traffic volumes on local streets may increase exposure of businesses, increasing the market value of these properties, (2) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses

Table 6.3 *Toll Road Impact Matrix* (Additional Benefits and Burdens Imposed by Toll Roads on Communities)

Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads prior to public access to the road (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Tax revenues	√ Benefits - Examples: (1) new dense developments at toll road nodes (with work, shopping, and leisure destinations within close proximity) will have a positive effect on tax revenues, (2) higher property values in the vicinity of toll roads will have a positive effect on tax revenues	√ Benefits - Examples: (1) new dense developments at toll road nodes (with work, shopping, and leisure destinations within close proximity) will have a positive effect on tax revenues, (2) higher property values in the vicinity of toll roads will have a positive effect on tax revenues	√ Benefits - Examples: (1) new dense developments at toll road nodes (with work, shopping, and leisure destinations within close proximity) will have a positive effect on tax revenues, (2) higher property values in the vicinity of toll roads will have a positive effect on tax revenues	√ No additional benefits/burdens
Cultural Effects				
Archaeological sites	No additional benefits/burdens	No additional benefits/burdens	No additional benefits/burdens	No additional benefits/burdens
Cultural resources (e.g., historic sites, historic landmarks)	√ Burdens - Examples: (1) if the additional right-of-way for the toll plaza displaces a historic site, (2) if toll road access control makes access to cultural resources difficult or unpleasant (e.g., longer travel times)	√ Burdens - Example: (1) if the additional right-of-way for a toll plaza displaces a historic site	√ Burdens - Example: (1) if the additional right-of-way for a toll plaza displaces a historic site	√ Burdens - Examples: (1) if the additional right-of-way for the toll plaza displaces a historic site, (2) if toll road access control makes access to cultural resources difficult or unpleasant (e.g., longer travel times)
	√ Benefits - Example: (1) access to cultural places improves for those who can afford the toll if they can access more historic sites within a certain travel time budget	√ Fewer Benefits - Example: (1) if toll road improves access to cultural resources, members of the community who cannot afford the toll receive fewer benefits from the tolled facility	√ Fewer Benefits - Example: (1) if toll road improves access to cultural resources, members of the community who cannot afford the toll receive fewer benefits from the tolled facility	√ Benefits - Example: (1) toll roads provide better access to cultural resources than non-toll roads if drivers who can afford the toll can access more cultural resources within a certain travel time budget

Finally, the National Environmental Policy Act (NEPA) requires that the transportation agency distinguishes among and consider direct, indirect, and cumulative impacts associated with transportation investments, including toll roads. Box 6.1 provides the CEQ definitions for each of these types of impacts. The potential additional impacts included in the toll road impact matrix have to be reviewed in light of these definitions.

Box 6.1 Direct, Indirect and Cumulative Impacts Defined

"Effects" include:

(a) ***Direct effects*** [emphasis added], which are caused by the action and occur at the same time and place.

(b) ***Indirect effects*** [emphasis added], which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the patterns of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems." (Sec. 1508.8 Effects)

"***Cumulative impact***" [emphasis added] is the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (Sec. 1508.7 Cumulative impact)

6.4 CONCLUDING REMARKS

To determine the potential additional impacts (i.e., benefits and burdens) imposed by toll roads on EJ communities given the four toll road scenarios compared to non-toll roads, four key questions and examples of sub-questions were explored based on an in-depth literature review of (1) the potential ecological, mobility, safety, social, and economic impacts of highway investments, including priced facilities, and (2) the socio-demographic characteristics of the users of priced facilities. The outcome was a detailed

Toll Road Impact Matrix (see Table 6.3) that may be used by the transportation agency as a reference when identifying the additional benefits and burdens associated with toll roads (alternative 2) as compared to non-toll roads (alternative 1). The National Environmental Policy Act (NEPA) requires that the transportation agency distinguishes among and consider direct, indirect, and cumulative impacts associated with transportation investments. The direct, indirect, and cumulative effects suffered by EJ communities impacted by a toll road project could be very complex in such a way that it might become extremely difficult to distinguish between cause and effect.

Chapter 7 Steps 4 and 5: What is the Magnitude of the Additional Impacts? Are the EJ Communities Disproportionately Impacted by the Toll Road?

This chapter presents the fourth and fifth analysis/quantitative methodological steps of the proposed Environmental Justice Evaluation Methodology (EJEM): **What is the magnitude of the additional impacts? Are the EJ communities disproportionately impacted by the toll road?** (see Figure 3.1). Specifically, this chapter presents background information, the recommended analysis tools, and the quantitative approach for measuring and comparing the magnitude of the additional impacts imposed by a toll road on EJ communities relative to a non-toll road project. The recommended approach includes the required statistical tests and power analysis to assess whether EJ communities are disproportionately impacted and interpret the non-significant findings. *EJ indexes* are provided to assess impacts on accessibility, air and noise quality, residential and commercial property values, and pedestrian and bicycle safety. This chapter further describes and evaluates the analysis tools that can be used to calculate the *EJ indexes* in terms of data requirements, expertise required, potential data sources, limitations, robustness, and cost.

7.1 Methodologies to Assess EJ Impacts at the Project Level

The objective of the EJEM is to determine whether a toll road would burden EJ populations disproportionately as compared to non-EJ populations. This requires the measurement of the additional impacts—both positive and negative—that minority and low-income populations are most likely to experience as a result of the proposed toll road. Step 4 of the EJEM thus requires the measurement of the additional impacts associated with toll roads relative to non-toll roads. A number of methodologies and analysis techniques are available that can be used to quantify or qualitatively describe the EJ impacts (see Table 7.1).

Table 7.1 Methodologies to Assess EJ Impacts at the Project Level

Impact	Measure	Type of Analysis
Ecological Impacts	Air quality	Quantitative
	Noise	Quantitative
Socio-economic Impacts	Accessibility to employment, shopping and community services	Quantitative and Qualitative
	Community cohesion	Quantitative and Qualitative
	Displacement	Quantitative
	Safety and security	Qualitative
	Aesthetics	Qualitative
	Percent of income spend on transportation	Qualitative
	Economic development	Qualitative

Source: Adapted from Cambridge Systematics, Inc. (2002)

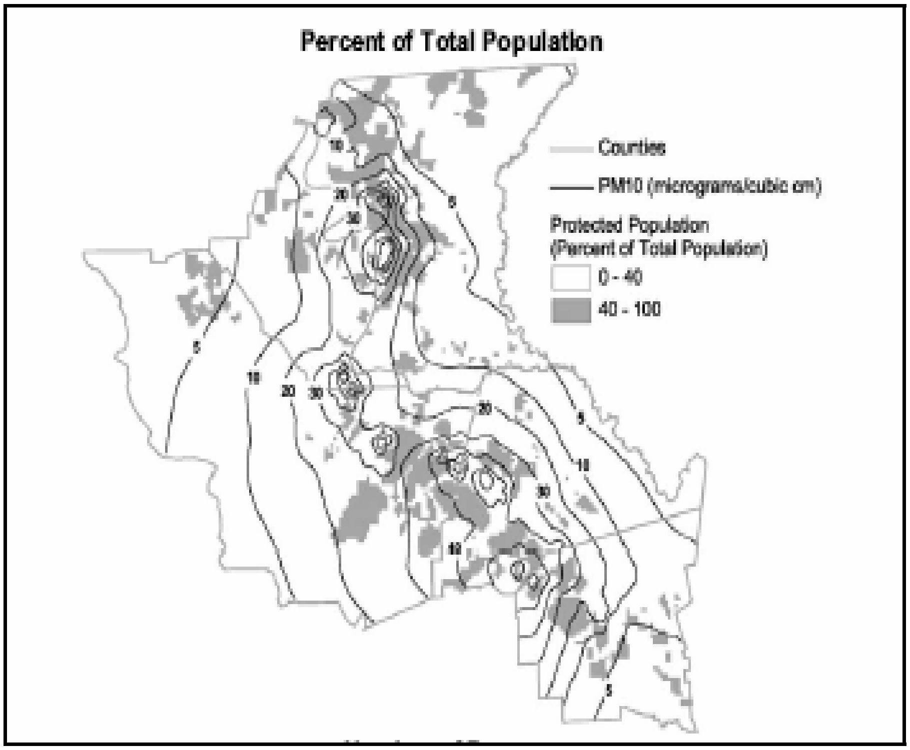
The literature review provided insights into the strengths and weaknesses of the traditional types of analysis tools and models available for measuring the ecological and socio-economic impacts of transportation projects among different population groups. The following paragraphs provide a brief overview of the strengths and weaknesses of some of these analysis methods.

Questions, Interviews, and Panels are useful techniques to identify and collect information on the social and environmental impacts associated with a particular project. Information can be gathered through key person interviews with opinion leaders, indigenous peoples, and technical experts (Executive Office of the President, 1997). For example, researchers tend to use surveys and focus groups to determine the impacts of proposed transportation projects on community cohesion. Neighborhood surveys, however, only measure community cohesion at a specific point in time. In other words, neighborhood surveys cannot be used to predict how cohesion might be affected by a significant change in the community. Focus groups can be used in situations where the views of a few knowledgeable participants are considered representative of the majority view, a technique recommended for use in small communities in which cohesion is weak to moderate or in medium-sized communities where cohesion is strong (Forkenbrock and Weisbrod, 2001).

Checklists detailing likely impacts associated with a particular project can provide a framework for analysis. This might prevent important impacts from being ignored. At the same time, checklists are repeatable, provide consistency when similar projects are evaluated, and can present information in a concise manner. Checklists might, however, be incomplete, list a number of irrelevant impacts, or double-count impacts (Executive Office of the President, 1997).

Modeling, such as air quality models and travel demand models, can be used to quantify the cause and effect relationships of specific projects. In addition, simulation models can be used to simulate the environmental and socioeconomic effects of various actions over time and space. Developing project specific models are, however, costly in terms of resources, time, and data. In general, it is advised that an agency calibrate an existing and recognized model using collected baseline data rather than develop a new model. Sophisticated models also necessitate numerous assumptions, which can taint the likelihood of public understanding and acceptance of model outputs (Executive Office of the President, 1997). For example, traditional transportation air quality assessment methods—both micro-scale and regional air quality assessment methods—have been found to have severe limitations in revealing disproportionate or adverse impacts on EJ populations at the project level (Bachman et al., 2000). The micro-scale methodologies, such as CALINE and CAL3QHC, provide an indication of how populations at "worst case sites"[10] (i.e., hot spot sites) are affected. The results can, however, not be extrapolated beyond the evaluated sites and therefore, it cannot be used to assess the variability in pollutant levels across exposed population groups. At the same time, regional air quality models, such as MOBILE6, assume a relatively uniform distribution of pollutants across the study area. Because the analysis does not allow for geographical disaggregation below the regional level, it is impossible to compare the magnitude of the emissions impacts by population group. Air quality analysis using pollution surfaces, such as CALRoads View, on the other hand, provides the regional variability in air quality (see Figure 7.1) that the above two cited methods fail to provide. Pollution surface analysis is, however, extremely data intensive and has not yet received the level of regulatory approval that the micro-scale analysis and regional air quality assessment methods have (Forkenbrock and Sheeley, 2004).

[10] Typically around intersections in the study area.



Source: Forkenbrock and Sheeley (2004)

Figure 7.1 PM_{10} Concentration Levels and Protected Population Areas within a Regional Study Area

Urban travel forecasting models have traditionally been used to estimate the impacts of transportation projects on trip distance and the spatial distribution of trips (Federal Highway Administration, 1983). Newer activity-based approaches can, in addition, consider the interdependences in the trip decisions made by individuals (RDC, Inc., 1995). According to Forkenbrock and Sheeley (2004), the Transportation Analysis and Simulation System (TRANSIMS) is a state-of-the–art, activity-based model that can (a) replicate a virtual metropolitan region with a completely disaggregated population and (b) simulate the movements of individual travelers across the transportation network using multiple modes. The model can thus forecast how infrastructure investments might impact individual trips by time of day and forecast the impacts on different subpopulation groups (e.g., EJ communities) by considering their demographic characteristics. As stated earlier, simulation models are, however, costly in terms of resources, time, and data.

Overlay Mapping and Geographic Information Systems (GIS) allow the analyst to (1) overlay the socio-demographic characteristics of the impacted community and the anticipated impacts and (2) assess whether the measured impacts affect minority or low-income communities disproportionately compared to non-EJ communities. These map overlays can also be very useful in communicating adverse impacts and proposed mitigation options to the impacted communities.

Economic Impact Analysis determines the economic impacts and well-being of a community by considering the changes in business activity, employment, income, and population attributable to an activity, such as toll road building. Economic models (i.e., economic base models, input-output models, and econometric models) can be very complex and data intensive, but, in general, economic models are invaluable in the analysis of economic impacts (Executive Office of the President, 1997).

Social Impact Analysis entails the subjective perception of impacts. This type of analysis appraises the impacts of particular activities on certain key social variables. Key social variables include: population characteristics (e.g., the ethnic and racial diversity of the community), community and institutional structures (e.g., the activities of religious organizations), political and social resources (e.g., the leadership capacity within the community), individual and family changes (e.g., changes in family and community networks), and perceptions of risk, health, and safety. A number of methods can be used to determine social effects, including linear trend analysis, expert testimony, and simulation modeling (Executive Office of the President, 1997).

This research provides guidance on the use of a number of tools (see Table 7.2) and analysis methodologies to quantify the additional impacts of toll roads in terms of accessibility, air and noise quality, residential and commercial property values, and pedestrian and bicycle safety as conceptualized in the *Toll Road Impact Matrix*. The study further evaluated the proposed tools in terms of data needs, robustness, assumptions, required expertise, and cost (see Section 7.3).

Table 7.2 Recommended Tools to Measure the Additional Impacts

Effect	Impact	Recommended Tool
Mobility	Access to work Access to educational facilities Access to healthcare facilities Access to shopping centers	✓ TransCAD ✓ UrbanSim
Physical Environmental Quality	Air quality	✓ CALRoads View (CALINE4 + CAL3QHC + CAL3QHCR) ✓ MOBILE 6.2 ✓ EPA's CAMx ✓ SURFER (contours of pollutant concentrations)
	Noise quality	✓ FHWA's Traffic Noise Model (TNM)
Economic Development	Residential property values Commercial property values	✓ Property comparison (Appraiser's Opinion) ✓ UrbanSim
Social	Pedestrian safety	✓ Pedestrian Danger Index
	Bicycle safety	✓ Bicycle Safety Index

Once the additional impacts are quantified, the results can be overlaid with the EJ concentration zones to compare the impacts among zones with different concentration levels of EJ populations.

7.2 What is the Magnitude of the Additional Impacts? Are the EJ Communities Disproportionatelly Impacted by the Toll Road?

Step 5 of the EJEM thus attempts to determine whether the impacts imposed by a toll road on zones with high[11] and medium concentrations of EJ populations are statistically significantly higher compared to zones with low[12] concentrations of EJ populations. Figure 7.2 provides a graphical representation of the vertical and horizontal comparisons that need to be undertaken. First, the analyst needs to determine whether the measured impacts (Step 4) with the toll road (alternative 2) are statistically significantly higher than the measured impacts with the non-toll road (alternative 1) by EJ concentration level (i.e., vertical comparison shown in Figure 7.2). Second, if a statistically significant impact is imposed by the toll road, the analyst needs to determine whether the impact imposed on zones with high and medium concentrations of EJ populations are statistically significantly higher than the impact imposed on zones with low concentrations of EJ populations (i.e., horizontal comparison shown in Figure 7.2). Finally, the non-significant findings should be interpreted by estimating the power of the statistical test.

[11] In this chapter zones with extremely high and high concentrations of EJ populations (see Chapter 5) are referred to as zones with high concentrations of EJ populations

[12] In this chapter zones with no or small concentrations of EJ populations (see Chapter 5) are referred to as zones with low concentrations of EJ populations.

Alternatives	EJ Concentration Zones					
	Low		Medium		High	
1 (non-toll road condition)	MI_{01}	↕	MI_{02}	↕	MI_{03}	↕
2 (toll road condition)	MI_{11}	↔	MI_{12}	↔	MI_{13}	↔

Notes: MI = measured impact
↕ = comparison between the toll and non-toll alternatives
↔ = comparison between impacted EJ concentration zones given a statistically significant impact

Figure 7.2 Comparisons Required to Determine Significant Impacts

Although no clear federal guidance exists on what is a disproportionate or adverse impact, obviously if zones with high concentrations of EJ populations incur most of or significantly more of the burdens associated with a toll project compared to zones with low concentrations of EJ populations, there is cause for concern.

In summary, the overall objective of the EJEM is to determine whether a toll road would burden EJ populations disproportionately compared to a non-toll road. This requires the following:

- measuring the impacts by EJ concentration zones imposed by the non-toll road and toll road (alternatives 1 and 2, respectively);
- determining whether the measured impacts with the toll road (alternative 2) are statistically significantly higher than the measured impacts with the non-toll road (alternative 1) by EJ concentration level;
- if a statistically significant impact is imposed by the toll road, the analyst subsequently needs to determine whether the impact imposed on zones with high and medium concentrations of EJ populations are statistically significantly higher than the impact imposed on zones with low concentrations of EJ populations; and
- interpreting the statistically non-significant findings.

The literature revealed that a number of studies have employed statistical analysis to estimate location of minority and low-income populations and their proximity to hazardous facilities. Previous research has focused mainly on the locations of such population groups in relation to toxic chemical releases, rather than to transportation facilities. It also has tended to emphasize existing circumstances (e.g., whether minority populations are suffering injustice from a current site) rather than seeking to predict EJ concerns that might occur if a site or transportation facility were to be constructed (i.e., whether EJ populations would be disproportionately impacted by a proposed toll road).

7.2.1 Statistical Test

The statistical test to determine whether there is a statistically significant difference between the impacts imposed by the toll road compared to the non-toll road is the "paired *t* test." This test, based on differences between paired observations (one observation pertain to the toll road condition and the other observation pertain to the non-toll road condition) determines whether the mean difference between the quantified impacts of the toll road and non-toll road alternatives is statistically significant for zones with low, medium, and high concentrations of EJ populations. To test whether the mean difference is statistically significant, a one-sample *t* test (based on n *-1* degrees of freedom) on the differences is carried out. The statistical test is described in Box 7.1.

Given that a statistically significant impact (burden) is imposed by the toll road, the statistical tests to determine whether the impact on zones with high and medium concentrations of EJ populations is significantly higher than on zones with low concentrations of EJ populations are the "two-sample *t* test" and the "normal curve test for two population proportions." The former is concerned with the testing of hypotheses pertaining to difference between two independent means while the latter is based on the difference between two independent population proportions. A statistically significant difference exists if the observed difference in the mean/proportion of the impacted zones with high and medium concentrations of EJ populations and the mean/proportion of the impacted zones with low concentrations of EJ populations cannot be explained by chance alone. The statistical tests are described in Boxes 7.2 and 7.3.

Box 7.1 The *t* Test for Differences Between Paired Observations ("paired *t* test")

Does the data suggest that zones with low/medium/high concentrations of EJ populations are disproportionately burdened by the toll road compared to the non-toll road at a α significance level (vertical comparison)?

$$\textit{Null hypothesis}: \quad H_o : \mu_k^D = 0$$

$$\textit{Test statistic value}: \quad t = \frac{\bar{d}_k}{s_k^D / \sqrt{n_k}}$$

Alternative hypothesis	Re*jection region for approximate level α test*
$H_a : \mu_k^D > 0$	$t \geq t_{\alpha, n-1}$
$H_a : \mu_k^D < 0$	$t \leq -t_{\alpha, n-1}$

where

$\mu_k^D = \mu_k^2 - \mu_k^1$ = the mean difference between impacts imposed by alternatives 2 and 1 on the "*k*" concentration level of EJ populations

$\bar{d}_k$ = sample mean of the differences within pairs $\left(d_j^{'} s\right)$ for the "*k*" concentration level of EJ populations since:

$d_j = I_j^2 - I_j^1$ = difference between *measured impacts* imposed by alternatives 2 and 1

respectively pertain to observation "*j*" $(j \in k)$

I_j^A = *measured impact* imposed by alternative *A* pertain to observation "*j*" $(j \in k)$

A = sub-index for alternative (*A* = 1, 2)

s_k^D = standard deviation of the differences within pairs $\left(d_j^{'} s\right)$ for the "*k*" concentration level

of EJ populations

n_k = number of observations with "*k*" concentration level of EJ populations

k = sub-index for EJ concentration level (*k* = low, medium, high)

If H_o can be rejected at a α significance level, it can be concluded that zones with low/medium/high concentrations of EJ populations are disproportionally burdened by the toll road condition compared to the non-toll road.

Box 7.2 The *t* Test for the Difference Between Means ("two-sample *t* test")

Does the data suggest that the impact imposed on zones with medium/high concentrations of EJ populations is higher than on zones with low concentrations of EJ populations at a α significance level (horizontal comparison)?

$$\textit{Null hypothesis:} H_o : \mu^2_{medium} - \mu^2_{low} = 0 \qquad \textit{Alternative hypothesis:} H_a : \mu^2_{medium} - \mu^2_{low} < 0$$

$$\textit{Test statistic value}: \quad t = \frac{\bar{I}^2_{medium} - \bar{I}^2_{low}}{\sqrt{\frac{s^2_{medium}}{n_{medium}} + \frac{s^2_{low}}{n_{low}}}}$$

$$\text{Rejection region for approximate level } \alpha \text{ test:} \quad t \le -t_{\alpha,v}$$

$$\text{since} \quad v = \frac{\left(\frac{s^2_{medium}}{n_{medium}} + \frac{s^2_{low}}{n_{low}}\right)^2}{\frac{\left(s^2_{medium}/n_{medium}\right)^2}{n_{medium}-1} + \frac{\left(s^2_{low}/n_{low}\right)^2}{n_{low}-1}}$$

$$\textit{Null hypothesis}: H_o = \mu^2_{high} - \mu^2_{low} = 0 \qquad \textit{Alternative hypothesis}: H_a : \mu^2_{high} - \mu^2_{low} < 0$$

$$\textit{Test statistic value}: \quad t = \frac{\bar{I}^2_{high} - \bar{I}^2_{low}}{\sqrt{\frac{s^2_{high}}{n_{high}} + \frac{s^2_{low}}{n_{low}}}}$$

$$\text{Rejection region for approximate level } \alpha \text{ test}: \quad t \le -t_{\alpha,v}$$

$$\text{since} \quad v = \frac{\left(\frac{s^2_{high}}{n_{high}} + \frac{s^2_{low}}{n_{low}}\right)^2}{\frac{\left(s^2_{high}/n_{high}\right)^2}{n_{high}-1} + \frac{\left(s^2_{low}/n_{low}\right)^2}{n_{low}-1}}$$

where:

$\mu^2_{medium} - \mu^2_{low}$ = the mean difference between impacts imposed by alternative 2 on the medium and low concentration levels of EJ populations, respectively

$\mu^2_{high} - \mu^2_{low}$ = the mean difference between impacts imposed by alternative 2 on the high and low concentration levels of EJ populations, respectively

$\bar{I}^2_k$ = the sample mean of the *measured impact* imposed by alternative 2 on the "*k*" concentration level of EJ populations

s^2_k = the sample variance of the *measured impact* imposed by alternative 2 on the "*k*" concentration level of EJ populations

n_k = number of observations with "*k*" concentration level of EJ populations

k = sub-index for EJ concentration level (k = low, medium, high)

If H_o can be rejected at a α significance level, it can be concluded that zones with medium/high concentrations of EJ populations are disproportionally impacted by the toll road compared to zones with low concentrations of EJ populations.

Box 7.3 The z Test for the Difference Between Population Proportions
("normal curve test for two population proportions")

	EJ Concentration Levels		
	Low	Medium	High
Proportions pertain to alternative 2 (toll road)	$\hat{p}^2_{low} = \dfrac{I^2_{low}}{n_{low}}$	$\hat{p}^2_{medium} = \dfrac{I^2_{medium}}{n_{medium}}$	$\hat{p}^2_{high} = \dfrac{I^2_{high}}{n_{high}}$

$$\hat{p}_{ml} = \frac{n_{medium}}{n_{medium} + n_{low}} \hat{p}^2_{medium} + \frac{n_{low}}{n_{medium} + n_{low}} \hat{p}^2_{low} \qquad \hat{q}_{ml} = 1 - \hat{p}_{ml}$$

$$\hat{p}_{hl} = \frac{n_{high}}{n_{high} + n_{low}} \hat{p}^2_{high} + \frac{n_{low}}{n_{medium} + n_{low}} \hat{p}^2_{low} \qquad \hat{q}_{hl} = 1 - \hat{p}_{hl}$$

where:

$\hat{p}^2_k$ = impact proportion for the "*k*" concentration level of EJ populations and alternative *2*

I^2_k = *measured impact* imposed by alternative 2 on the "*k*" concentration level of EJ populations

n_k = number of observations with "*k*" concentration level of EJ populations

k = sub-index for EJ concentration level (*k* = low, medium, high)

Hypothesis Testing

Does the data suggest that the impact imposed on zones with medium/high concentrations of EJ populations is higher than on zones with low concentrations of EJ populations at a α significance level (horizontal comparison)?

$$\textit{Null hypothesis} \quad H_o : p^2_{medium} - p^2_{low} = 0$$

$$\textit{Alternative hipotheses} \quad H_a : p^2_{medium} - p^2_{low} > 0$$

$$\textit{Test statistic value (large samples)} : z = \frac{\hat{p}^2_{medium} - \hat{p}^2_{low}}{\sqrt{\hat{p}_{ml}\hat{q}_{ml}\left(1/n_{medium} + 1/n_{low}\right)}}$$

$$\textit{Rejection region for approximate level } \alpha \textit{ test} : \quad z \geq z_\alpha$$

$$\textit{Null hypothesis} \quad H_o : p^2_{high} - p^2_{low} = 0$$

$$\textit{Alternative hypothesis} \quad H_a : p^2_{high} - p^2_{low} > 0$$

$$\textit{Test statistic value (large samples)} : z = \frac{\hat{p}^2_{high} - \hat{p}^2_{low}}{\sqrt{\hat{p}_{hl}\hat{q}_{hl}\left(1/n_{high} + 1/n_{low}\right)}}$$

$$\textit{Rejection region for approximate level } \alpha \textit{ test} : \quad z \geq z_\alpha$$

If H_o can be rejected at a α significance level, it can be concluded that zones with medium/high concentrations of EJ populations are disproportionally impacted by the toll road compared to zones with low concentrations of EJ populations.

7.2.2 Statistical Power

Power analysis is recommended to interpret the results of non-significant findings (i.e., fail to reject that there is no difference between paired observations/two means/two population proportions at the α significance criterion). A growing number of researchers have argued that with a large sample size, the null hypothesis (i.e., the hypothesis that the phenomenon to be demonstrated is in fact absent) is likely to be rejected (Hays, 1981, p. 293). As a result, sometimes a lack of significance may reflect a sample of insufficient size more so that the phenomenon being study is absent. These remarks argue for critically analyzing the meaning of rejections of the null hypothesis by reporting the *practical* significance of the findings (e.g., the magnitude of effect), in addition to the *statistical* significant which cannot be separated from sample size.

Through power analysis the probability that the statistical test detects effects of a specific size (*ES*) at a specified significance level (α), given the sample size (*n*) and the nature of the test (i.e., one-tailed or two-tailed test) can be estimated. Specifically, the power of a statistical test is the probability of rejecting the null hypothesis if in fact the null hypothesis is false (or the probability of rejecting the null hypothesis when the alternative hypothesis is true). That is,

$$\boxed{Power = 1 - probability\ of\ Type\ II\ error = 1 - \beta}$$

As implied before, the power of the test depends upon three parameters: the significance level (α), the sample size (*n*), and the effect size (*ES*). When α, the probability of committing a type I error, increases, power increases. Generally the power of a statistical test increases with an increase in *n*. The *ES* serves as an index of degree of departure from the null hypothesis; it takes the value of zero when the null hypothesis is true and some other specific nonzero value when the null hypothesis is false. In general, the larger the *ES*, the greater the power.

Cohen (1977) proposes definitions for small, medium, and large *ES* in psychological research for *t* test in terms of *d* (the difference between group means in standard deviation units) and suggested that $d = 0.20$ is a small *E*S, $d = 0.50$ is a medium *ES*, and $d = 0.80$ is a large *ES*. Cohen (1988), however, urges researchers to interpret *ES* in the context of relevant, previous research in their specific areas, and use his definitions only when no other information is available. Because no previous studies exist on applied statistical power analysis in the context of EJ assessment of transportation projects, power analysis using Cohen's conventional small, medium, and large *ES* are adopted in this research to interpret the non-significant findings when comparing the toll road and non-toll road alternatives.

The central point of power analysis in the context of EJ assessment of toll road projects is to reveal the power of the test, including those of trivial power, because a test must have adequate power in order for non-significant results to be interpretable. Box 7.4 describes how to compute the power of the recommended statistical tests to assess whether a toll road would burden EJ populations disproportionally compared to non-toll road. The power of the test is estimated as a function of the significance level (α) and the sample size (*n*). The analysts should keep in mind the following: (a) α should be set at .05 or .01 to maintain acceptable levels of Type I error, (b) the sample size depends on the number of observations with low, medium, and high concentration of EJ populations, and (c) the effect size exists in the populations so that it is not subject to manipulation by the analyst. Computer software for power calculations are listed in Box 7.5.

Box 7.4 Estimation of the Power of the Statistical Test

Paired t test Analysis		
Sample size (n_k)	Number of observations with "*k*" concentration level of EJ populations	
Effect size index (d)	$d = d_z^{'}\sqrt{2}$ since $d_z^{'} = \dfrac{\bar{d}_k}{s_k^D}$	
Power*	Published tables in Cohen (1988) for one-tailed test as a function of α, n_k, and d	
Two-sample *t* test		
Condition 1	$n_{medium} \neq n_{low}, \quad s_{medium}^2 = s_{low}^2 = s_{ml}^2$	$n_{high} \neq n_{low}, \quad s_{high}^2 = s_{low}^2 = s_{hl}^2$
Sample size (n')	$n' = \dfrac{2\, n_{medium}\, n_{low}}{n_{medium} + n_{low}}$	$n' = \dfrac{2\, n_{high}\, n_{low}}{n_{high} + n_{low}}$
Effect size index (d)	$d = \dfrac{\bar{I}_{medium}^2 - \bar{I}_{low}^2}{\sqrt{s_{ml}^2}}$	$d = \dfrac{\bar{I}_{high}^2 - \bar{I}_{low}^2}{\sqrt{s_{hl}^2}}$
Power**	Published tables in Cohen (1988) for one-tailed test as a function of α, n', and d	
Condition 2	$n_{medium} = n_{low}, \quad s_{medium}^2 \neq s_{low}^2$	$n_{high} = n_{low}, \quad s_{high}^2 \neq s_{low}^2$
Sample size (n')	$n = n_{medium} = n_{low}$	$n = n_{high} = n_{low}$
Effect size index (d)	$d = \dfrac{\bar{I}_{medium}^2 - \bar{I}_{low}^2}{s'}$ since $s' = \sqrt{\dfrac{s_{medium}^2 + s_{low}^2}{2}}$	$d = \dfrac{\bar{I}_{high}^2 - \bar{I}_{low}^2}{s'}$ since $s' = \sqrt{\dfrac{s_{high}^2 + s_{low}^2}{2}}$
Power**	Published tables in Cohen (1988) for one-tailed test as a function of α, n, and d	
Normal curve test for two population proportions		
Condition	$n_{medium} \neq n_{low}$	$n_{high} \neq n_{low}$
Sample size (n')	$n' = \dfrac{2\, n_{medium}\, n_{low}}{n_{medium} + n_{low}}$	$n' = \dfrac{2\, n_{high}\, n_{low}}{n_{high} + n_{low}}$
Effect size index (h)	$h = \phi_{medium}^2 - \phi_{low}^2$ since $\phi_k^2 = 2\arcsin\sqrt{\hat{p}_k^2}$	$h = \phi_{high}^2 - \phi_{low}^2$ since $\phi_k^2 = 2\arcsin\sqrt{\hat{p}_k^2}$
Power***	Published tables in Cohen (1988) for one-tailed test as a function of α, n' and h	

Notes:
*Tables 2.3.1, 2.3.2, and 2.3.3 for α = .01, .05, and .10, respectively.
** Tables 2.3.1, 2.3.2, and 2.3.3 for α = .01, .05, and .10, respectively. For normal populations of substantially different sizes and substantially unequal variance, the nominal values of *t* and power at a given α may differ greatly from the true values. Under these conditions the values in Tables 2.3 may be greatly in error.
**Tables 6.3.1, 6.3.2, and 6.3.3 for α = .01, .05, and .10, respectively.

Box 7.5 Computer Software for Power Calculations

Software	URL resources	Comment
nQuery Advisor Release 4.0	http://www.statsol.ie	Sample size and power calculations for a given standard deviation and effect size
SamplePower(r) 1.2	http://www.spss.com/spower/research.htm	Available from SPSS, it estimates sample sizes for a variety of common data analysis situations
G*Power	http://www.psychologie.uni-trier.de:8000/projects/gpower.html	To calculate a sample size for a given effect size, alpha level, and power level (free of charge)
UnityPow	http://www.bio.ri.ccf.org/power.html	A freeware SAS module/macro that performs sample size and power analysis

Source: High (2000)

7.3 Mobility Impacts

This section explains the calculation of a number of accessibility indices that can be used to measure the benefits and burdens associated with toll roads (relative to non-toll roads) on impacted EJ communities given the four defined toll scenarios. Accessibility refers to the numbers and types of destinations (i.e., jobs, educational facilities, healthcare facilities, and recreational facilities) available to EJ communities within an established travel time threshold and given a specific transportation mode.

7.3.1 Accessibility to Work Index

The *accessibility to work index for zone i* (W_i) is defined as the number of employment opportunities (i.e., jobs) available to the population (in zone *i*) within an established travel time (travel distance) threshold and given a specific transportation mode (e.g., number of jobs that can be reached within 30 minutes by car).

The recommended steps to assess whether EJ populations will incur a disproportionate burden in terms of employment opportunities with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively) are the following:

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of employment opportunities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll road alternatives. Based on model results, estimate employment impacts associated with both alternatives (e.g., new jobs generated at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate the number of employment opportunities that can be reached within the established travel time threshold and transportation mode for each EJ concentration zone given alternatives 1 (W_i^1) and 2 (W_i^2).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to employment by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test", based on paired data analysis since

$H_0 : \mu_k^D = 0$

$H_a : \mu_k^D < 0$

$d_i = W_i^2 - W_i^1 =$ difference between *accessibility to work indexes for zone i* for alternatives 2 and 1, respectively $(i \in k)$

$n_k =$ number of zones with "*k*" concentration level of EJ populations

i = sub-index for zone

Step 7: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to employment) than zones with low concentrations of EJ populations by applying the "two-sample *t* test" since

$\bar{I}_k^2 = \overline{W}_k^2 =$ *the mean accessibility to work index* imposed by alternative 2 on the "*k*" concentration level of EJ population

Step 8: Interpret the non-significant findings by estimating the power of the statistical tests.

Box 7.6 provides an example to illustrate steps 5 and 6 of the proposed approach.

Box 7.6 Analysis of Paired Data Using a One-Sample *t* Test

A transportation agency is considering the conversion of a planned non-toll road into a toll road prior to the opening of the road to the public. To assess whether a disproportionate impact will be imposed, access to employment by EJ concentration zone has been estimated using TransCAD. The table below shows the number of employment opportunities that can be reached within 30 minutes by car, in zones with high concentrations of minority and low-income populations given the two alternatives. Does the data suggest that the number of employment opportunities accessible within 30 minutes by car in zones with high concentrations of EJ populations is significantly less, given the toll road compared with the non-toll road, at a 0.05 significance level?

	Number of jobs accessible within 30 minutes by car		
Zones with high concentrations of EJ populations	**Toll road condition** (W_i^2)	**Non-toll road condition** (W_i^1)	Difference (d_i)
1	19	15	4
2	21	20	1
3	18	22	-4
4	5	8	-3
5	34	25	9
6	12	17	-5

The hypothesis of interest is $H_0 : \mu_k^D = 0$ (versus $H_a : \mu_k^D < 0$). At level 0.05, H_o should be rejected if $t \leq -t_{0.05,5} = -2.015$. Since the value of the test statistic is 0.15, H_o cannot be rejected. Therefore, the data suggest that access to employment in zones with high concentrations of minority and low-income population is the same given the toll road and non-toll road conditions at a 0.05 significance level.

7.3.2 Accessibility to Educational Facilities Index

The *accessibility to educational facilities index for zone i* (E_i) is defined as the number of educational facilities (i.e., schools, colleges, universities, and libraries) available to the population (in zone *i*) within an established travel time (travel distance) threshold and given a specific transportation mode (e.g., number of colleges that can be reached within 45 minutes by bus).

The recommended steps to assess whether EJ populations will incur a disproportionate burden in terms of access to educational facilities with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively) are the following:

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of educational facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll road alternatives. Based on model results, estimate changes in the number and location of educational facilities with both alternatives (e.g., new colleges or relocation of university campuses at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate the number of educational facilities that can be reached within the established travel time threshold and transportation mode for each EJ concentration zone given alternatives 1 (E_i^1) and 2 (E_i^2).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to educational facilities by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test" based on paired data analysis since

$H_0 : \mu_k^D = 0$

$H_a : \mu_k^D < 0$

$d_i = E_i^2 - E_i^1$ = difference between *accessibility to educational facilities indexes for zone i* for alternatives 2 and 1, respectively $(i \in k)$

n_k = number of zones with "*k*" concentration level of EJ populations

i = sub-index for zone

Step 7: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to educational facilities) than zones with low concentrations of EJ populations by applying the "two-sample *t* test" since

$\bar{I}_k^2 = \bar{E}_k^2 =$ *the mean accessibility to educational facilities index* imposed by alternative 2 on the "*k*" concentration level of EJ population

Step 8: Interpret the non-significant findings by estimating the power of the statistical tests.

7.3.3 Accessibility to Healthcare Facilities

The *accessibility to healthcare facilities index for zone i* (H_i) is defined as the number of healthcare facilities (i.e., hospitals, community health centers, and clinics) available to the population (in zone *i*) within an established travel time (travel distance) threshold and given a specific transportation mode (e.g., number of hospitals that can be reached within 30 minutes by car).

The recommended steps to assess whether EJ populations will incur a disproportionate burden in terms of access to healthcare facilities with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively) are the following:

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of healthcare facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll road alternatives. Based on model results, estimate changes in the number and location of healthcare facilities with both alternatives (e.g., new hospitals or relocation of clinics at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate the number of healthcare facilities that can be reached within the established travel time threshold and transportation mode for each EJ concentration zone given alternatives 1 (H_i^1) and 2 (H_i^2).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to healthcare facilities by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test" since

$H_0 : \mu_k^D = 0$

$H_a : \mu_k^D < 0$

$d_i = H_i^2 - H_i^1 =$ difference between *accessibility to healthcare facilities indexes for zone i* for alternatives 2 and 1, respectively $(i \in k)$

$n_k =$ number of zones with "*k*" concentration level of EJ populations

i = sub-index for zone

Step 7: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to healthcare facilities) than zones with low concentrations of EJ populations by applying the "two-sample *t* test" since

$\bar{I}_k^2 = \overline{H}_k^2 =$ *the mean accessibility to healthcare facilities index* imposed by alternative 2 on the "*k*" concentration level of EJ population

Step 8: Interpret the non-significant findings by estimating the power of the statistical tests.

7.3.4 Accessibility to Shopping Facilities

The *accessibility to shopping facilities index for zone i* (S_i) is defined as the number of shopping facilities available to the population (in zone *i*) within an established travel time (travel distance) threshold and given a specific transportation mode (e.g., number of malls that can be reached within 25 minutes by car).

The recommended steps to assess whether EJ populations will incur a disproportionate burden in terms of access to shopping facilities with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively) are the following:

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of shopping facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll roads. Based on model results, estimate changes in the number and location of shopping facilities with both alternatives (e.g., new shopping centers at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate the number of shopping facilities that can be reached within the established travel time threshold and transportation mode for each EJ concentration zone given alternatives 1 (S_i^1) and 2 (S_i^2).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to shopping facilities by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test", based on paired data analysis since:

$H_0 : \mu_k^D = 0$

$H_a : \mu_k^D < 0$

$d_i = S_i^2 - S_i^1 =$ difference between *accessibility to shopping facilities indexes for zone i* for alternatives 2 and 1, respectively $(i \in k)$

$n_k =$ number of zones with "*k*" concentration level of EJ populations

i = sub-index for zone

Step 7: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to shopping facilities) than zones with low concentrations of EJ populations by applying the "two-sample *t* test" since

$\bar{I}_k^2 = \bar{S}_k^2 =$ *the mean accessibility to shopping facilities index* imposed by alternative 2 on the "*k*" concentration level of EJ population

Step 8: Interpret the non-significant findings by estimating the power of the statistical tests.

7.3.5 Accessibility to Recreational Facilities

The *accessibility to recreational facilities index for zone i* (R_i) is defined as the number of recreational facilities (e.g., parks, pools, and playgrounds) available to the population (in zone i) within an established travel time (travel distance) threshold and given a specific transportation mode (e.g., number of pools that can be reached within 20 minutes by car).

The recommended steps to assess whether EJ populations will incur a disproportionate burden in terms of access to recreational facilities with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively) are the following:

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car, transit or walk) for the analysis.

Step 3: Collect data on the number of recreational facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll roads. Based on model results, estimate changes in the number and location of recreational facilities with both alternatives (e.g., new recreational centers at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate the number of recreational facilities that can be reached within the established travel time threshold and transportation mode for each EJ concentration zone given alternatives 1 (R_i^1) and 2 (R_i^2).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to recreational facilities by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test," based on paired data analysis since:

$H_0 : \mu_k^D = 0$

$H_a : \mu_k^D < 0$

$d_i = R_i^2 - R_i^1$ = difference between *accessibility to recreational facilities indexes for zone i* for alternatives 2 and 1, respectively y $(i \in k)$

n_k = number of zones with "*k*" concentration level of EJ populations

i = sub-index for zone

Step 7: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to recreational facilities) than zones with low concentrations of EJ populations by applying the "two-sample *t* test" since

$\bar{I}_k^2 = \bar{R}_k^2 =$ *the mean accessibility to recreational facilities index* imposed by alternative 2 on the "*k*" concentration level of EJ population

Step 8: Interpret the non-significant findings by estimating the power of the statistical tests.

7.3.6 Data and Sources

To calculate the *accessibility indexes*, information about the number of employment opportunities (i.e., jobs), educational institutions (e.g., schools, colleges, universities, and libraries), healthcare facilities (e.g., hospitals, community health centers, and clinics), shopping facilities (e.g., malls) and recreational facilities (e.g., parks, pools, and playgrounds) within the area impacted by the toll road is required. The information needed may be obtained from a number of public and private sources.

Employment information may be obtained from Metropolitan Planning Organizations (MPOs), which use employment data at the Traffic Analysis Zone (TAZ) level in travel demand forecasting models (i.e., trip generation, trip distribution, mode choice, and traffic assignment).Information about local businesses may also be obtained from the local chamber of commerce. Finally, the community data catalog of ESRI (ESRI: Community Tapestry) contains proprietary business data for more than 10 million U.S. businesses. The catalog includes the following information: business name and location, franchise code, industrial classification code, number of employees, and sales volume (current as of January 2005) (ESRI: Business Data).

Information about educational, healthcare, shopping, and recreational facilities may be obtained from MPOs, school districts, and cities. When estimating the number of trips generated by the travel demand-forecasting models, MPOs typically identify special generators within their jurisdictions, including universities and colleges, hospitals, shopping malls, and recreational facilities. . School districts are repositories for school data in their area. Some cities have developed GIS data files that illustrate the spatial location of schools, colleges, libraries, hospitals, health clinics, and recreational facilities. For example, the City of Austin's GIS Data Sets' webpage (City of Austin, 2005) provides map data files that illustrate the geographic location of educational institutions, hospitals, city parks, county parks, and recreation centers in Austin.

Proprietary data about healthcare, educational, and shopping facilities may be acquired from ESRI (ESRI Home Page). For example, *ESRI Data & Map* (ESRI Data and Maps) contain map data files of hospitals, medical centers, schools and colleges at different geographic scales. ESRI's *Directory of Major Malls (DMM)* (ESRI: Shopping Center Locator) includes information about more than 3,900 major shopping centers and malls with 225,000 square feet or more of gross leasable space.. Finally, other sources of information that should be explored include Google Earth® (Google Earth Home Page) and Google Maps® (Google Maps Home Page).

The data obtained from both public and private data sources should, however, be validated and complimented through field surveys (e.g., windshield surveys), especially if the proposed toll road project has raised concerns about access to work, and educational, healthcare, shopping, and recreational facilities by an EJ community.

7.3.7 Robustness and Limitations of the Proposed Analysis Method

Calculating the *accessibility indexes* requires expertise in travel demand models, land use models, Geographic Information Systems (GIS), and spatial analysis. It is assumed that the travel demand model is able to determine the travel time impacts imposed by the toll road and that the land use model may be used to estimate locations of (a) new employment generated at nodes (i.e., interchanges) and along connectors of the toll and non-toll roads, and (b) new educational, healthcare, shopping, and recreational facilities or their relocation at nodes (i.e., interchanges) and along connectors of the toll and non-toll roads. The robustness of the approach is thus a function of the level to which the travel demand and land use models can differentiate the impacts on travel time, employment, and location of educational, healthcare, shopping, and recreational facilities associated with the proposed toll road. The two commercial software packages available to calculate the *accessibility indexes* are TransCAD (Caliper Corp.) and UrbanSim (UrbanSIM Home). The cost of TransCAD ranges between \$3,000 and \$10,000 (based on 2005 data); UrbanSim is available free of charge.

7.4 PHYSICAL ENVIRONMENTAL QUALITY EFFECTS

This section explains the calculation of a number of air quality and noise indices that can be used to measure the benefits and burdens associated with toll roads (as compared to non-toll roads) on impacted EJ communities given the four defined toll scenarios.

7.4.1 Air Quality Index

The *air quality at grid g index* (AQI_g) is defined as the pollutant concentrations (expressed in ppm) at the grid level (i.e., cells) associated with the non-toll and toll road alternatives. Tools available to estimate pollutant concentrations are **CALRoads View, Mobile 6.2**, **CAMx**, and **Surfer® 8**.

7.4.1.1 Data and Sources

CALRoads View, an air dispersion modeling package, can be used for predicting the pollutant concentrations near roadways for an unlimited number of grids in a region (Lakes Environmental Software). The modeling package combines the features of three mobile source dispersion models: CALINE4 (Coe et al, 1998), CAL3QHC (U.S. EPA, 1995), and CAL3QHCR. CALRoads View estimates the concentration of carbon monoxide (CO), particulate matter (PM), nitrogen dioxide (NO_2), and inert gases in ppm at ½ hr, 1-hr and 8-hr intervals at the grid level. The required input data and potential data sources to run CALRoads View are presented in Tables 7.3, 7.4, and 7.5.

Table 7.3 CAL3QHC/ CAL3QHCR: Input Data and Potential Data Sources

Variables		Potential Data Sources
Meteorological	Average Time [min]	User Input
	Surface Roughness Coefficient [cm]	Field Data
	Settling Velocity [cm/s]	Determined by analyst
	Deposition Velocity [cm/s]	Determined by analyst
	Wind Speed [m/s]	Field Data
	Stability Class [1 to 6 = A to F]	Determined by analyst
	Mixing Height [m]	Determined by analyst
Site	Roadway Coordinates [X,Y,Z] [m or ft]	Field Data
	Roadway Width [m or ft]	Field Data
	Receptor Coordinates [X,Y,Z] [m or ft]	Field Data
Traffic	Traffic Volume [each link] [veh/hr]	Field Data
	Traffic Speed [each link] [mi/hr]	Field Data
	Average Signal Cycle Length [each intersection] [s]	Field Data
	Average Red Time Length [each approach] [s]	Field Data
	Clearance Lost Time [s]	Field Data
	Saturation Flow Rate [veh/hr]	Field Data
	Signal Type [pre-timed, actuated, or semi-actuated]	Field Data
	Arrival Rate [worst, below average, average, above average, best progression]	Field Data
Emissions	Composite Running Emission Factor [each free flow link] [g/vehicle mile]	MOBILE6.2
	Idle Emission Factor [each queue link] [g/vehicle-hour]	MOBILE6.2
	Background Concentration levels of CO & PM	Field Data

Source: U.S. EPA (1995)

Table 7.4 CALINE4: Input Data Variables and Potential Data Sources

Variables		Potential Data Sources
Job Parameters	Run Type	User Input
	Aerodynamic Roughness Coefficient	Table G.6
Model Information	Link/Receptor Geometry Units	Field Data
	Altitude above Sea Level	Field Data
	Number of Links	Field Data
	Averaging Interval	User Input
	Link Type	Field Data
	Link Height	Field Data
Link Activity	Traffic Volume	Field Data
	Emission Factor	EMFAC model or MOBILE6.2
Run Conditions	Mixing Zone Width	Field Data
	Wind Speed	Field Data
	Wind Direction	Field Data
	Wind Direction Standard Deviation	Field Data
	Atmospheric Stability Class	Field Data
	Mixing Height	User Input (< 10 m)
	Ambient Temperature	Field Data
	Ambient Pollutant Concentration	Field Data
Receptor Conditions	Number of Receptors	Field Data
	Endpoint Coordinates	Field Data

Source: Coe et al (1998)

Table 7.5 Aerodynamic Roughness Coefficient

Roughness Coefficient (cm)	Landscape Type
0.002	Sea, paved areas, snow-covered flat plain, tide flat, smooth desert
0.5	Beaches, pack ice, morass, snow-covered fields
3	Grass prairie or farm fields, tundra, airports, heather
10	Cultivated areas with low crops and occasional obstacles (such as bushes)
25	High crops, crops with varied height, scattered obstacles (such as trees or hedgerows), vineyards
50	Mixed far fields and forest clumps, orchards, scattered buildings
100	Regular coverage with large obstacles, open spaces roughly equal to obstacle heights, suburban houses, villages, mature forests
≥ 200	Centers of large towns or cities, irregular forests with scattered clearings.

Source: Stull, R.B. (1995)

The MOBILE 6.2 model can be used to estimate emissions from on-road mobile sources, such as passenger cars, trucks, heavy trucks, buses, and motorcycles (U.S. EPA, 2003). MOBILE 6.2 uses a fleet-wide average emission rate for each class or type of vehicle to estimate an emission rate for the region. In addition, the emissions rate per unit time and the daily, annual, or hourly vehicle travel (e.g., VMT/day, VMT/year, or VMT/hr) is needed. The data required to run MOBILE 6.2 and potential data sources are shown in Table 7.6. The model results are expressed in grams per vehicle miles traveled (g/VMT).

Table 7.6 MOBILE6.2: Input Data Variables and Potential Data Sources

Variable	Potential Data Source
Month (January, July)	Field Data
Hourly temperature	Field Data
Altitude (high, low)	Field Data
Weekend/weekday	Field Data
Fuel characteristics (Reid vapor pressure, sulfur content, oxygenate content, etc.)	Field Data
Humidity and solar load	Field Data
Registration (age) distribution by vehicle class	Field Data
Annual mileage accumulation by vehicle class	Field Data
Diesel sales fractions by vehicle class and model year	Field Data
Average speed distribution by hour and roadway	User Input
Distribution of vehicle miles traveled by roadway type	Field Data
Engine starts per day by vehicle class and distribution by hour	Field Data
Engine start soak time distribution by hour	Field Data
Trip end distribution by hour	Field Data
Average trip length distribution	User Input
Hot soak duration	Field Data
Distribution of vehicle miles traveled by vehicle class	Determined by analyst
Full, partial, and multiple diurnal distribution by hour	Determined by analyst
Inspection and maintenance (I/M) program description	Field Data
Anti-tampering inspection program description	Field Data
Stage II refueling emissions inspection program description	Field Data
Natural gas vehicle fractions	Field Data
HC species output	Field Data
Particle size cutoff	Field Data
Emission factors for PM and HAPs	Field Data
Output format specifications and selections	Field Data
Background concentration levels of , PM_{10}, $PM_{2.5}$, CO, NO_2, and SO_2 for purpose of calibration.	Field Data
Non-residential land use data for generating contours using TransCAD	Field Data

Source: U.S. EPA (2003)

Once the emissions rates for the region is determined (using Mobile 6.2), a regional dispersion model, such as CAMx, can be used to forecast pollutant concentrations on a regional scale (ENVIRON, 2004). Table 7.7 presents the data required to run CAMx and potential data sources. The results from the model are expressed in ppm for each grid.

Once the pollutant concentrations (in ppm) are estimated at the grid level from either CALRoads or Mobile 6.2 and CAMx, commercial software packages, such as Surfer® 8, can then be used to generate pollutant contours for the impacted region (Golden Surface Inc.). The input data required for Surfer® 8 are the coordinates of the receptors and the estimated pollutant concentrations in ppm. The output data from Surfer® 8 are the pollutant contours in a raster structure.

Table 7.7 CAMx: Input Data Variables and Potential Data Sources

Variable	Potential Data Source
Meteorology	Supplied by meteorological model
3-Dimensional Gridded Fields:	
Horizontal Wind Components	
Temperature	
Pressure	
Water Vapor	
Vertical Diffusivity	
Clouds/Rainfall	
Air Quality	Obtained from measured ambient data
Gridded Initial Concentrations	
Gridded Boundary Concentrations	
Time/Space Constant Top Concentrations	
Emissions	Supplied by an emissions model
Elevated Point Sources	
Gridded Sources:	
Low-level Point	
Mobile	
Area/Non-road Mobile	
Biogenic	
Geographic	Provided by land use/land cover maps
Gridded Land Use/Surface Cover	
Gridded Surface UV Albedo Codes	
Ozone Column and Photolysis Rates	Ozone column from TOMS Data Photolysis rates from radioactive model
Vertical Grid Structure	
Atmospheric Radioactive Properties	
Gridded Haze Opacity Codes	
Gridded Ozone Column Codes	
Photolysis Rates Lookup Table	

7.4.1.2 Approach

The following steps are recommended to assess whether EJ populations will incur a disproportionate burden in terms of air quality (i.e., number of people exposed to a pollution threshold that exceeds the National Ambient Air Quality Standards) with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively).

Step 1: Determine air quality standards for each analyzed pollutant. The National Ambient Air Quality Standards (NAAQS) are summarized in Table 7.8. Some states and regions have, however, adopted stricter air quality standards.

Table 7.8 National Ambient Air Quality Standards (NAAQS)

Pollutant	Statistic	Standard Value*	Standard type
Ozone (O_3)	1-hour average	0.12 ppm (235 $\mu g/m^3$)	Primary & secondary
	8-hour average	0.08 ppm (157 $\mu g/m^{3)}$	Primary & secondary
Particulate (PM_{10})**	Annual arithmetic mean	50 $\mu g/m^3$	Primary & secondary
	24-hour average	150 $\mu g/m^3$	Primary & secondary
Particulate ($PM_{2.5}$)***	Annual arithmetic mean	15 $\mu g/m^3$	Primary & secondary
	24-hour average	65 $\mu g/m^3$	Primary & secondary
Carbon monoxide (CO)	8-hour average	9 ppm (10 mg/m^3)	Primary
	1-hour average	35 ppm (40 mg/m^3)	Primary
Nitrogen dioxide (NO_2)	Annual arithmetic mean	0.053 ppm (100 $\mu g/m^3$)	Primary & secondary
Sulfur dioxide	Annual arithmetic mean	0.030 ppm (80 $\mu g/m^3$)	Primary
	24-hour average	0.14 ppm (365 μgm^3)	Primary
	3-hour average	0.50 ppm (1300 $\mu g/m^3$)	Secondary

* Parenthetical value is an approximately equivalent concentration.
** Particles with aerodynamic diameters of 10 micrometers or less
*** Particles with aerodynamic diameters of 2.5 micrometers or less
Source: U.S. EPA (2003)

Step 2: Compile the EJ concentration zones within the impacted area.

Step 3: Identify all receptors (e.g., houses, office buildings, schools, hospitals, and nursing homes) potentially impacted. For example, identify all receptors within <u>300 m</u> on each side of the non-toll and toll road alternatives (Zhu et al, 2002).

Step 4: Collect all input data required for the selected model(s) for alternatives 1 and 2.

Step 5: Run the selected model(s) to estimate the individual pollutant concentrations in ppm for all the grids in the impacted area for the non-toll and toll road alternatives (i.e., AQI_g^1 and AQI_g^2, respectively).

Step 6: Use Surfer® 8 to map the individual pollutant concentration levels at the grid level for the impacted area with the non-toll and toll road alternatives, respectively. Categorize the grids by EJ concentration level by overlaying the Surfer® 8 model results with the EJ concentration zones.

Step 7: Determine whether the toll road imposes a statistically significant air quality impact (in terms of each of the individual pollutants) by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test" based on paired data analysis since

$H_0 : \mu_k^D = 0$

$H_a : \mu_k^D > 0$

$d_g = AQI_g^2 - AQI_g^1 =$ difference between *air quality indexes at grid g* (for the analyzed pollutant) for alternatives 2 and 1, respectively $(g \in k)$

$n_k =$ number of grids with "*k*" concentration level of EJ populations

g = sub-index for grids

Step 8: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether the grid population in zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of pollutant concentrations) than grid populations in zones with low concentrations of EJ populations by calculating the impacted population in each grid and applying the "normal curve test for two population proportions" based on differences between population proportions since

$\hat{p}_k^2 =$ proportion of grid population impacted by poor air quality given alternative 2 for the "*k*" concentration level of EJ populations

$I_k^2 = AQAP_k^2 =$ grid population impacted by poor air quality given alternative 2 for the "*k*" concentration level of EJ populations

$n_k =$ total population for the "*k*" concentration level of EJ populations

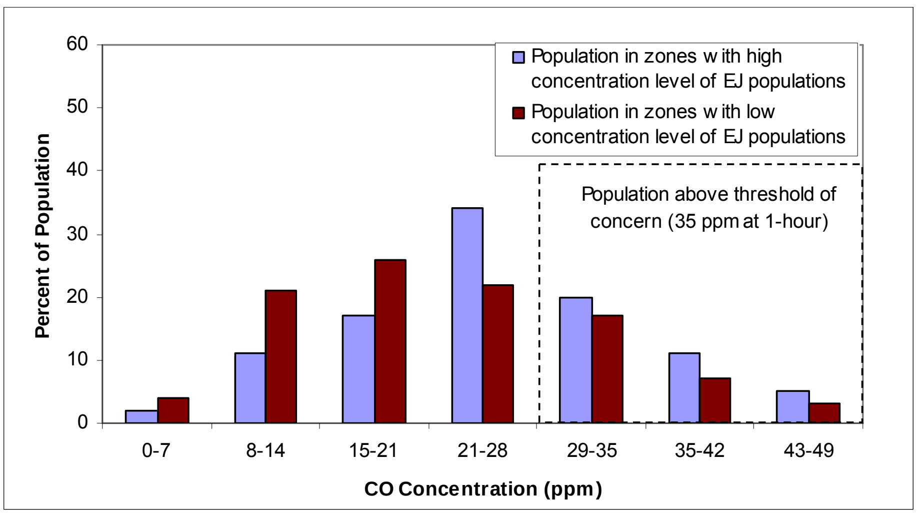
Step 9: Interpret the non-significant findings by estimating the power of the statistical tests.

Box 7.7 provides an example to illustrate steps 7 and 8 of the proposed approach.

Box 7.7 Assessing Disproportionate Air Quality Impacts Based on Population Proportions

An air quality analysis using CALRoads View reveals that neighborhoods adjacent to frontage roads of toll road facilities may be exposed to high concentrations of carbon monoxide (CO). The affected population groups by EJ concentration levels have been identified (see Table and Figure below) by overlaying the EJ concentration zones in the impacted area with the pollution surfaces (grids).

CO Concentrations at 1-hour (ppm)	Grid Population by EJ Concentration Level	
	High	**Low**
0-7	269	169
8-14	1,477	888
15-21	2,282	1,100
21-28	4,565	931
29-35	2,685	719
35-42	1,477	296
43-49	671	127
Total	**13,425**	**4,230**



Do the data suggest that the proportion of grid population impacted by poor air quality in zones with high concentration level of EJ populations is higher than that for zones with low concentration level of EJ populations at a 0.01 significance level?

	Grid Population by EJ Concentration Level		Total
	High	**Low**	
Total population in the impacted area	m = 13,425	n = 4,230	17,655
Population affected by CO concentrations > 35 ppm at 1-hour	x = 4,833	y = 1,142	5,975
Population proportions	$\hat{p}^2_{high} = 0.36$	$\hat{p}^2_{low} = 0.27$	$\hat{p} = 0.27$

The hypothesis of interest is $H_0 : p^2_{high} - p^2_{low} = 0$ versus $H_a : p^2_{high} - p^2_{low} > 0$. At level 0.01, H_o should be rejected if $Z \geq Z_{.01}$ =2.33. Since the value of the test statistic is 10.79, H_o must be rejected. The p-value is so minuscule that at any reasonable level α, H_o must be rejected. Therefore the data suggest that the grid population in zones with high EJ concentration level is disproportionately impacted by CO concentrations compared with the grid population in zones with low EJ concentration level at a 0.01 significance level. Power of the test (the probability of rejecting H_o when H_a is true) = 0.995. Effect size = 0.19.

7.4.1.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *air quality at grid g index* requires expertise in air quality models, pollution surface analysis, GIS, and spatial analysis. CALRoads View can be used to estimate pollutant concentrations for an unlimited number of receptors and grids in a region. MOBILE 6.2 can be used for regional-scale modeling but is less appropriate for project-level analysis when site-specific real-time fleet emissions are needed (Keller, 2002). CAMx is an air quality dispersion model that can be used to model pollutant concentrations for a whole region at a very disaggregate level. It is assumed that the selected air quality models can capture the pollutant impacts with the non-toll and toll roads. The robustness of the approach is thus a function of the extent to which the selected model(s) can differentiate pollutant concentrations associated with the two alternatives. CALRoads View and Surfer® 8 cost $995 and $599, respectively (based on 2005 data); MOBILE 6.2 and CAMx are available free of charge.

7.5 Noise Quality Index

The *noise quality at receiver r index* (NQI_r) is defined as the traffic noise level at receiver *r* associated with the non-toll and toll road alternatives.

7.5.1.1 Data and Sources

The Federal Highway Administration (FHWA)'s Traffic Noise Model (TNM) can be used (a) to predict traffic noise levels near highways and (b) design noise barriers to effectively mitigate traffic noise impacts. The model predicts the noise level at specific receivers considering (a) traffic parameters, (b) road information, (c) type of terrain surface, (d) receiver coordinates, including distance between receiver and road center line, (e) the presence (or absence) of a noise barrier, and (f) if present, the height of the noise barrier. Table 7.9 lists the data required to run TNM and potential data sources.

Table 7.9 FHWA's TNM: Input Data and Potential Data Sources

Traffic Information	Potential Data Source
Volume	Field Data
Vehicle classification information (based on five standard vehicle types)	Field Data
Average vehicle speeds for each vehicle type and for constant and interrupted traffic flow	Field Data
Road Information	**Potential Data Source**
Horizontal and vertical alignment (X,Y, and Z coordinates of the oad[s])	Shape file*
Terrain Surface Information	**Potential Data Source**
Type of Surface	Field Data
Receiver Information	**Potential Data Source**
Number of receivers and coordinates	Field Data
For each receiver, type and distance from center line of the road	Shape file*
Barrier Information	**Potential Data Source**
Barrier Present	Field Data
Barrier Height	Field Data

*ArcView shapefiles capturing the required information can be imported into TNM (Keller, 2002)

The model output is the noise level at each receiver considered in the analysis. Noise contours can also be generated using the contour features of the software (FHWA, 2005).

7.5.1.2 Approach

The following steps are recommended to determine whether EJ populations at receivers (e.g., houses, office buildings, schools, hospitals, and nursing homes) will incur a disproportionate burden in terms of noise quality with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively).

Step 1: Determine the noise abatement criteria (NAC) by receiver type. A decibel (dB) is the most often used noise measurement unit. The human ear has different levels of sensitivity to high-pitched and low-pitched sounds. Therefore highway traffic noise measurements are adjusted to approximate human hearing. These adjusted measurements are known as A-weighted decibels (dBA). The NAC is thus defined in hourly A-weighted decibels expressed as L_{EQ}(h) or L_{10}(h). Table 7.10 lists the current FHWA NAC (Federal Highway Administration, 2005).

Table 7.10 FHWA's Hourly NAC (A-weighted Sound Level in dBA)

Activity Category	L_{EQ}(h)	L_{10}(h)	Description of Activity Category
A	57 (Exterior)	60 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to fulfill its intended purpose.
B	67 (Exterior)	70 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (Exterior)	75 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	None	None	Undeveloped lands.
E	52 (Interior)	55 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: Federal Highway Administration, 1995, p. 7.

Step 2: Compile the EJ concentration zones within the impacted area.

Step 3: Identify all receivers (e.g., houses, office buildings, schools, hospitals, and nursing homes) potentially impacted. For example, identify all receivers within 60 m on each side of the non-toll and toll road alternatives for a lightly traveled road or within 150 m on each side of the non-toll and toll road alternatives for a heavily traveled road (Forkenbrock and Sheeley, 2004).

Step 4: Collect all input data required for the model for alternatives 1 and 2.

Step 5: Estimate the noise levels at all the identified types of receivers in the impacted area for the non-toll and toll road alternatives (i.e., NQI_r^1 and NQI_r^2, respectively). Categorize the receivers by EJ concentration levels by overlaying the model results with the EJ concentration zones.

Step 6: Determine whether the toll road imposes a statistically significant noise quality impact (for each receiver type) by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test," based on paired data analysis since

$$H_0 : \mu_k^D = 0$$
$$H_a : \mu_k^D > 0$$

$d_r = NQI_r^2 - NQI_r^1$= difference between the *noise quality indexes at receiver r* (for each receiver type) by EJ concentration level for alternatives 2 and 1, respectively ($r \in k$)

n_k =number of receivers with "*k*" concentration level of EJ populations

r = sub-index for receivers

Step 7: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level) , determine whether the population at receivers in zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of noise levels exceeding the NAC) than populations at receivers in zones with low concentrations of EJ populations by calculating the impacted population at each receiver and applying the "normal curve test for two population proportions" based on differences between population proportions since

$\hat{p}_k^2$ =proportion of receiver population impacted by poor noise quality given alternative 2 for the "*k*" concentration level of EJ populations.

$I_k^2 = NQAP_k^2$ =receiver population impacted by poor noise quality given alternative 2 for the "*k*" concentration level of EJ populations

n_k = total population for the "*k*" concentration level of EJ populations

Step 8: Interpret the non-significant findings by estimating the power of the statistical tests.

Box 7.8 provides an example to illustrate steps 7 and 8 of the proposed approach.

Box 7.8 Inferences Concerning a Difference between Population Proportions

A traffic noise quality analysis using FHWA's TNM reveals that receivers adjacent to a toll road facility will be exposed to noise levels that exceed the FHWA's noise abatement criteria (i.e., 67 dBA). The affected population groups by EJ concentration levels have been identified by overlaying the EJ concentration zones in the impacted area with the model results (see table below). Do the data suggest that the proportion of population (at receivers) impacted by excessive traffic noise in zones with high EJ concentration levels is higher than that for zones with low EJ concentration levels at a 0.05 significance level?

	Receiver Population by EJ Concentration Level		Total
	High	Low	
Total population in the impacted area	13,230	8,425	21,655
Population exposed to noise level > 67 dBA	4,197	3,422	7,619
Population proportions	$\hat{p}^2_{high} = 0.45$	$\hat{p}^2_{low} = 0.41$	$\hat{p} = 0.35$

The hypothesis of interest is $H_0 : p^2_{high} - p^2_{low} = 0$ versus $H_a : p^2_{high} - p^2_{low} > 0$. At level 0.05, H_o should be rejected if $Z \geq Z_{.05}$ =1.645. Since the value of the test statistic is 6.50, H_o must be rejected. The p-value is so minuscule that at any reasonable level α, H_o must be rejected. Therefore the data suggest that the population at receivers in zones with high EJ concentration level is disproportionately impacted by higher noise levels compared with the population at receivers in zones with low EJ concentration level at a 0.05 significance level. Power of the test (the probability of rejecting H_o when

7.5.1.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *noise quality at receiver r index* requires expertise in traffic noise models, GIS, and spatial analysis. The FHWA's TNM can estimate the traffic noise at up to 45 discrete receivers in one run. To obtain results for more than 45 receivers, multiple runs are required. Also, the TNM allows for the drawing of noise level contours. These contours can be overlaid with the EJ concentrations zones to visualize the noise impacts across the impacted area. It is thus assumed that the TNM can capture the noise impacts with the non-toll and toll road condition. The robustness of the approach is thus a function of the extent to which the TNM model can differentiate the traffic noise levels associated with the two alternatives. The FHWA's TNM (Version 2.5) costs $595 (based on 2005 data). The software is available from the McTrans Center at the University of Florida.

7.5 Economic Development Effects

This section explains how to calculate an index that can be used to measure the burdens imposed by toll roads (compared to non-toll roads) on the residential and commercial property values (e.g., houses, buildings, and land) on impacted EJ communities given the four defined toll scenarios.

7.5.1 Residential and Commercial Property Value Index

The *residential and commercial property value index at grid g* (PVI_g) is defined as the differential in property values at the grid level associated with the non-toll and toll road alternatives. Available tools to estimate the change in property values are Property Comparison/Appraiser's Opinion and UrbanSim.

7.5.1.1 Data and Sources

Property Comparison/Appraiser's Opinion is widely used by property appraisers to determine the values of residential and commercial properties (Forkenbrock and Sheeley, 2004). In conducting the analysis, an appraiser identifies recently sold properties—known as *comp*s—in the vicinity with characteristics similar to the property being appraised. The sale price is subsequently adjusted to yield the appraised value of the property in question after considering property characteristics, such as dwelling age, physical characteristics, location amenities, and downsides. The required input data and potential data sources for the Property Comparison method are listed in Table 7.11. If more than one appraiser is used, a brief report should be compiled providing the range of the likely changes in the appraised property values.

Table 7.11 Property Comparison: Input Data Variables and Potential Data Sources

Physical characteristics	Potential Data Sources
Number of rooms	Field data
Floor area	Field data
Construction quality	Professional opinion (civil engineer)
Piping condition	Professional opinion (civil engineer)
Transportation access	Accessibility indices
Amenities	**Potential Data Sources**
School rating	Public opinion
Safety	Public opinion
Downsides	**Potential Data Sources**
Crime	Police records, public opinion
Noise	Public opinion

UrbanSim is a transportation and urban land use model. The theoretical basis of the model is founded in random utility maximization (RUM) theory, bid rent theory on land markets, and hedonic price theory (Waddell and Ulfarsson, 2002). UrbanSim consists of a family of models that are embedded and interact within a software architecture that facilitates the implementation of these models (see Figure 7.3). Some of the processing models include: (a) *Economic and Demographic Models*, (b) a *Location Choice Model*, (c) a *Household and Employment Mobility Model*, (d) a *Real Estate Development Model*, and (e) a *Land Price Model*. The latter two models are used for estimating changes in property values.

The *Real Estate Development Model* and *Land Price Model* in UrbanSim use a multinomial logit (MNL) structure for estimating land prices. The *Real Estate Development Model* simulates developers' choices concerning where and what type of construction to undertake, including new developments and redeveloping existing structures. The steps are as follows:

- The model examines all grids/cells on which development is allowed and creates a list of possible development alternatives, including the alternative of not developing (Waddell, 2002).

- The probability for each alternative being selected is calculated using a MNL model.
- The development is then simulated using a Monte Carlo sampling process.
- Finally, the most likely characteristics of the resulting development project within the grid/cell are estimated using a development template. This template has defined probability distributions for development changes, such as the number of housing units, the square feet of residential, industrial, and government space, the improvement value, and the construction schedule (Waddell, 2002).

The *Real Estate Development Model* simulates the choices of a developer or land-owner at a single location (grid/cell) about whether to develop and what type of real estate to invest in. This decision is influenced by market information about the state of the market, such as vacancy rates. The variables included in this model are:

- characteristics of the grid/cell (i.e., current development, policy constraints, land and improvement value),
- characteristics of the site location (i.e., proximity to highways, arterials, existing development, and recent development), and
- regional accessibility to population.

The *Land Price Model* is founded in urban economic theory, which states that the value of location is reflected in the price of the land (Waddell, 2002). The model simulates changes in land prices at each grid/cell resulting from changes in the characteristics of the locations over time. The land value for each cell is calculated as the sum of the land values of the parcel fragments[13] within the cell. This cell value is used as

[13] These values originate from the tax assessor's estimates of the land value of each parcel.

the dependent variable in the land price model. The model is calibrated from historical data using a hedonic regression that includes the effect of site, neighborhood, accessibility, and policy effects on land prices. The model also considers the effects of short-term fluctuations in local and regional vacancy rates on overall land prices.

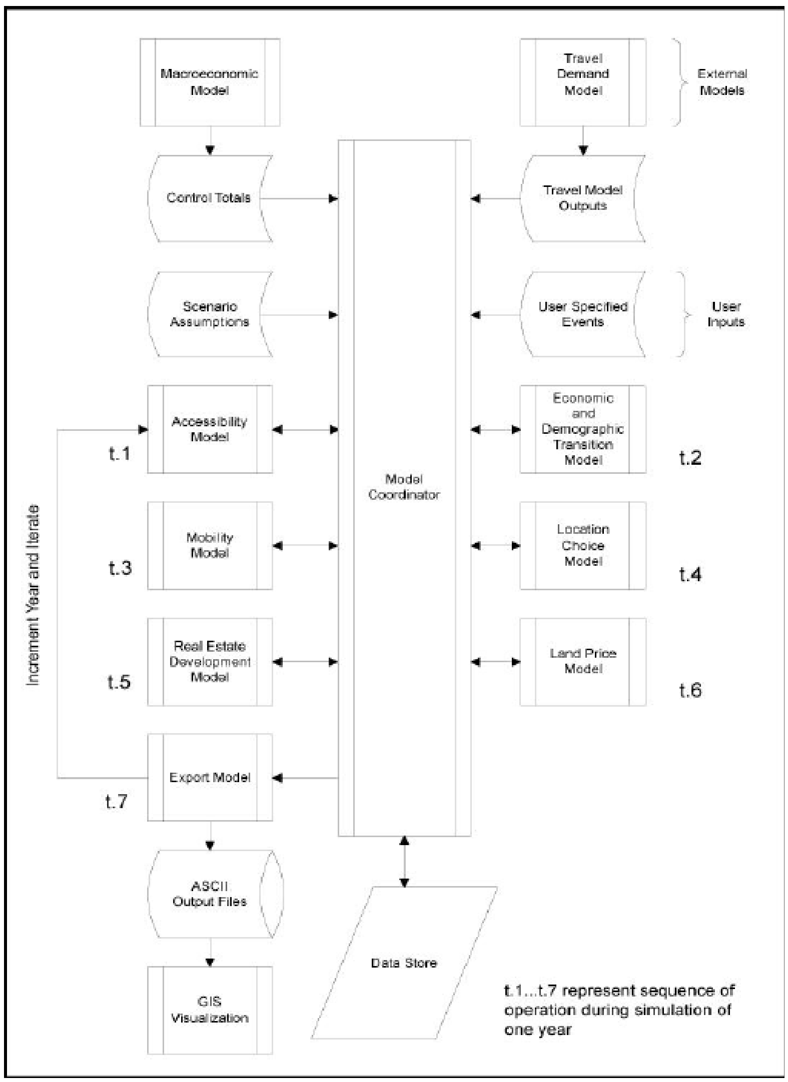


Figure 7.3 UrbanSim Model Structure and Processing

Table 7.12 lists the input data variables needed to estimate property values using UrbanSim. The input data for the model database, called the *data store*, require parcel files from tax assessor offices, business establishment files from the state unemployment insurance database, commercial sources, census data, GIS overlays, and a location grid. The data integration tools in UrbanSim read the *data store* and apply decision rules to synthesize missing or erroneous data. The *data store* represents location using grid cells of 150 meters x 150 meters. The location grid allows cross referencing to other spatial features such as planning and political boundaries (e.g., city, county, traffic analysis zones). A different cell size can be specified by the analyst.

Table 7.12 UrbanSIM: Input Data Variables

Variables	Sub-Variable
Household Information (HouseholdID)	Persons
	Workers
	Children
	Age of head
	Income
	GridID
Grid Information (GridID)	Total housing units
	Vacant housing units
	Total nonresidential area
	Vacant nonresidential area
	Development type
	Land value
	Environmental overlays
	Residential improvement value
	Non residential improvement value
	UGB, city, county, traffic zone
Job Information (JobID)	Sector
	GridID

7.5.1.2 Approach

The following steps are recommended to determine whether EJ populations will incur a disproportionate burden in terms of property values (i.e., number of properties that significantly increase or decrease in value) with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively).

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Collect all input data required for the selected tool (e.g., UrbanSim) for alternatives 1 and 2.

Step 3: Run UrbanSIM to estimate the property values for all grids in the impacted area for the non-toll and toll road (i.e., PVI_g^1 and PVI_g^2, respectively). Categorize the grids by EJ concentration level by overlaying the model results with the EJ concentration zones.

Step 4: Determine if the toll road imposes a statistically significant impact on property values (for each property type, such as residential, commercial or land) by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test" based on paired data analysis since

$H_0 : \mu_k^D = 0$
$H_a : \mu_k^D < 0$
$d_g = PVI_g^2 - PVI_g^1 =$ difference between *property value indexes at grid g* (for each property type) by EJ concentration level for alternatives 2 and 1, respectively $(g \in k)$
$n_k =$ number of grids with "*k*" concentration level of EJ populations
g = sub-index for grids

Step 5: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether properties in zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts than properties in zones with low concentrations of EJ populations by applying the "two-sample *t* test" since

$\bar{I}_k^2 = \overline{P}VI_k^2 =$ *the mean property value index* imposed by alternative 2 on the "*k*" concentration level of EJ population

Step 6: Interpret the non-significant findings by estimating the power of the statistical tests.

7.5.1.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *residential and commercial property value at grid g index* using Property Comparison/Appraiser's Opinion requires expertise in property markets and GIS. Calculating the index using UrbanSim requires expertise in land use models, GIS, and spatial analysis.

Property Comparison/Appraiser's Opinion may yield the best property values or estimates when sophisticated models are not readily available (Forkenbrock and Sheeley, 2004). The method can be implemented by consulting local professionals knowledgeable about local property markets or by hiring a firm with expertise in market studies. Although the latter option requires more effort in terms of systematic analysis, both options depend heavily on an understanding of the property markets (Forkenbrock and Sheeley, 2004). The most serious limitation of this method is the need to find good *comps*, that is, comparable properties which can be used to estimate impacts on property values within an area with reasonable accuracy. Furthermore, because this technique relies solely on appraisers' judgment, care should be taken in identifying good *comps* near toll road facilities that are similar to the toll alternative being analyzed. Since human judgments can vary widely, this method may not be suitable if similar properties cannot be found. In other words, without good *comps* this method may not yield an accurate forecast of changes in property values resulting from a toll road facility.

UrbanSim is a powerful tool for conducting EJ analysis of toll road projects that require a high degree of demographic resolution, because the analysis can be conducted at the grid level. This model is, however, data intensive and requires substantial calibration. Furthermore, the literature does not provide adequate evidence to verify if the modeling effort yields accurate estimates of residential property values.

Finally, the robustness of the approach is thus a function of the extent to which the selected tools can differentiate the impact on property values associated with the two alternatives. The cost of the Property Comparison/Appraiser’s Opinion technique is a function of the appraiser's fees, which could vary substantially from one appraiser to the next. UrbanSim is available free of charge.

7.6 Social Effects

This section explains the calculation of the Pedestrian Danger Index (PDI) and the Bicycle Safety Index (BSI), which can be used to measure the benefits and burdens associated with toll roads (as compared to non-toll roads) on impacted EJ communities given the four identified toll road scenarios.

7.6.1 Pedestrian Danger Index

The Surface Transportation Policy Project (STPP) developed the *Pedestrian Danger Index (PDI)* method to evaluate pedestrian safety at the county level in California (Forkenbrock and Sheeley, 2004). The scale of analysis of this method was modified (i.e., EJ concentration zones instead of county level) for the purpose of this study. The *PDI* is calculated to have a normalized value of 1 to 100 with 100 being the most dangerous in terms of pedestrian safety. The *PDI* can thus be used to categorize the pedestrian safety environment associated with the non-toll and toll road alternatives.

7.6.1.1 Data and Sources

Table 7.13 lists the required input data and potential data sources for estimating the PDI. The input data given the non-toll and the toll road alternatives are based on actual numbers collected from an area(s) where comparable facilities have been constructed in the past. Special attention should thus be given to ensure that the selected area(s) are in fact as similar as possible in terms of pedestrian trip distance, demographics, road geometry, traffic volume, and hazards created or relieved by the proposed non-toll and toll road alternatives, respectively.

Table 7.13 Pedestrian Danger Index: Input Data and Potential Data Sources

Input Data	Potential Data Sources
Population Data	U.S. Census Data
Pedestrian Crash Data	Department of Public Safety Highway Patrol
Pedestrian Exposure Data	U.S. Census data (i.e., number of employed residents walking to work)

*Source: Forkenbrock and Sheeley, (2004), pp. 156

7.6.1.2 Approach

The recommended steps to assess whether EJ populations will incur a disproportionate burden in terms of pedestrian safety with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively) are the following:

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Collect the required input data for the alternatives for each EJ concentration zone in the impacted area.

Step 3: Calculate the number of injuries (*NI*) for zone *i* divided by 1,000 people for alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road) as follows:

$$\left(\frac{NI}{1{,}000\ people}\right)_i^A = \left(\frac{pedestrian\ death\ \&\ injury\ rate}{population}\right)_i^A \times 1{,}000$$

where

i = sub-index for zone

A= sub-index for alternative (A=1, 2)

Step 4: For all zones i within the impacted area, calculate the pedestrian exposure rate for alternatives 1 and 2 as follows:

$$PER_i^A = \left(\frac{number\ of\ employed\ residents\ walking\ to\ work}{total\ number\ of\ workers}\right)_i^A$$

Step 5: For all zones i within the impacted area, estimate the unadjusted index value for alternatives 1 and 2 as follows:

$$\boxed{UIV_i^A = \frac{\left(\frac{NI}{1{,}000\ people} \right)_i^A}{PER_i^A}}$$

Step 6: Identify the maximum unadjusted index value for alternatives 1 and 2 (UIV_{Max}^1 and UIV_{Max}^2, respectively).

Step 7: For all zones i within the impacted area, calculate the *PDI* (adjusted to reflect a scale of 1 to 100) for alternatives 1 and 2 as follows:

$$\boxed{PDI_i^A = \left(\frac{UIV_i^A}{UIV_{Max}^A} \right) \times 100}$$

Step 8: Determine whether the toll road imposes a statistically significant impact in terms of pedestrian safety by EJ concentration level relative to the non-toll alternative by applying the "paired t test" based on paired data analysis since

$H_0 : \mu_k^D = 0$

$H_0 : \mu_k^D > 0$

$d_i = PDI_i^2 - PDI_i^1$ = difference between the *pedestrian danger indexes for zone i* for alternatives 2 and 1, respectively $(i \in k)$

n_k = number of zones with "k" concentration level of EJ populations

i = sub-index for zones

Step 9: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced pedestrian safety) than zones with low concentrations of EJ populations by applying the "two-sample t test" since:

$\bar{I}_k^2 = \overline{P}DI_k^2 =$ the *mean pedestrian danger index* imposed by alternative 2 on the "k" concentration level of EJ population

Step 10: Interpret the non-significant findings by estimating the power of the statistical tests.

7.6.1.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *Pedestrian Danger Index* requires expertise in pedestrian safety analysis, GIS, and spatial analysis. Limited data and a lack of suitable comparison areas may, however, prevent the calculation of the PDI. For example, for the non-toll road alternative, data on pedestrian exposure and accidents might not be available. For the toll road alternative, the calculation requires to compare similar areas in terms of demographics, specifically the degree to which the areas provide residence to EJ communities, and toll road characteristics. This can be problematic.

It is thus assumed that the required data can be collected and that the impacts on pedestrian safety associated with the toll road can be estimated using the PDI. The robustness of the approach is thus a function of the extent to which the PDI can capture and differentiate the pedestrian safety impacts associated with the two alternatives.

7.6.2 Bicycle Safety Index

The *Bicycle Safety Index* (*BSI*), developed by Davis (1987) and modified by Epperson (1994), is an approach for estimating how bicycle safety might be affected by changes in road attributes; it can be used to assess the bicycle safety environment associated with the non-toll and toll road alternatives.

7.6.2.1 Data and Sources

Tables 7.14 and 7.15 list the input data and potential data sources for estimating the *BSI*.

Table 7.14 Bicycle Safety Index: Input Data Variables and Potential Data Sources

Variables	Potential Data Sources
Traffic volume (AADT)	Highway Performance Monitoring System (HPMS) Field data
Road characteristics (number of lanes, lane width, etc.)	
Pavement factors	See Table F.13
Location factors pertaining to conditions that affect the cross traffic, limit sight distance, or restrict the safe operation of bicycles	

Table 7.15 Pavement and Location Factors

Pavement Factor	Value		Location Factor	Value
Cracking	0.5		Angled parking	0.75
Patching	0.25		Parallel parking	0.25
Weathering	0.25		Right-turn lane (full length)	0.25
Potholes	0.25		Raised median (solid)	-0.50
Rough road edge	0.25		Raised median (left-turn bays)	-0.35
Railroad crossing	0.25		Center turn lane (scramble lane)	-0.20
Rough railroad crossing	0.5		Paved shoulder	-0.75
Drainage grates	0.5		Grades, severe	0.50
			Grades, moderate	0.20
			Curves, frequent	0.35
			Restricted sight distance	0.50
			Numerous drives	0.25
			Industrial land use	0.25
			Commercial land use	0.25

Source: Epperson (1994).

7.6.2.2 Approach

The recommended steps to assess whether EJ populations will incur a disproportionate burden in terms of bicycle safety with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively) are the following:

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Collect the required input data for the two alternatives for each road segment.

Step 3: Calculate the *BSI* for each road segment "*s*" $\left(BSI_s^A\right)$ for alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road) as follows:

$$\boxed{BSI_s^A = \frac{AADT_s^A}{3100 \times L_s^A} + \frac{S_s^A}{48} + \left(\frac{S_s^A}{48} \times \left(4.25 - W_s^A\right) \times 1.635\right) + PF_s^A + LF_s^A}$$

where:

BSI$_i$ = *Bicycle Safety Index* for road segment "*s*" for alternative *A*
AADT = Average annual daily traffic for road segment "*s*" for alternative *A*
L = Number of traffic lanes for road segment "*s*" for alternative *A*
S = Speed limit (kilometers per hour) for road segment "*s*" for alternative *A*
W = Width of the outside lane (meters) for road segment "*s*" for alternative *A*
PF = Sum of pavement factors for alternative *A* (see Table F.13)
LF = Sum of location factors for alternative *A* (see Table F.13)
s = sub-index for road segment
A = sub-index for alternative (*A*=1, 2)

Step 4: Categorize the road segments by EJ concentration level by overlaying the results with the EJ concentration zones.

Step 5: Determine whether the toll road imposes a statistically significant impact in terms of bicycle safety by EJ concentration level relative to the non-toll alternative by applying the "paired *t* test" based on paired data analysis since

$H_0 : \mu_k^D = 0$
$H_0 : \mu_k^D > 0$
$d_s = BSI_s^2 - BSI_s^1 =$ difference between the *bicycle safety indexes for road segment "s"* for alternatives 2 and 1, respectively $(s \in k)$
$n_k =$ number of road segments with "*k*" concentration level of EJ populations
s = sub-index for road segment

Table 7.16 provides interpretations of *BSI* values.

Step 6: If a statistically significant impact (burden) is imposed by the toll road (i.e., H_o can be rejected at a α significance level), determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced bicycle safety) than zones with low concentrations of EJ populations by applying the "two-sample *t* test" since:

$\bar{I}_k^2 = \overline{B}SI_k^2 =$ the *mean bicycle safety index* imposed by alternative 2 on the "*k*" concentration level of EJ population

Table 7.16 Interpretation of *BSI* Values

Index range	Classification	Description
0 to 3	Excellent	Denotes an extremely favorable roadway for safe bicycle operation
3 to 4	Good	Refers to roadway conditions still conducive to safe bicycle operation, but not quite as unrestricted
4 to 5	Fair	Pertains to roadway conditions of marginal desirability for safe bicycle operation
5 or above	Poor	Indicates roadway conditions of questionable desirability for bicycle operation

Source: Epperson (1994)

Step 7: Interpret the non-significant findings by estimating the power of the statistical tests.

7.6.2.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *Bicycle Safety Index* requires expertise in bicycle safety analysis, GIS, and spatial analysis. Limited data may, however, prevent the calculation of the BSI. It is thus assumed that the required data can be obtained and that the impacts on bicycle safety associated with the toll road can be estimated using the BSI. The robustness of the approach is thus a function of the extent to which this index can capture and differentiate the bicycle safety impacts associated with the two alternatives.

Chapter 8 Step 6: What are Potential Mitigation Options?

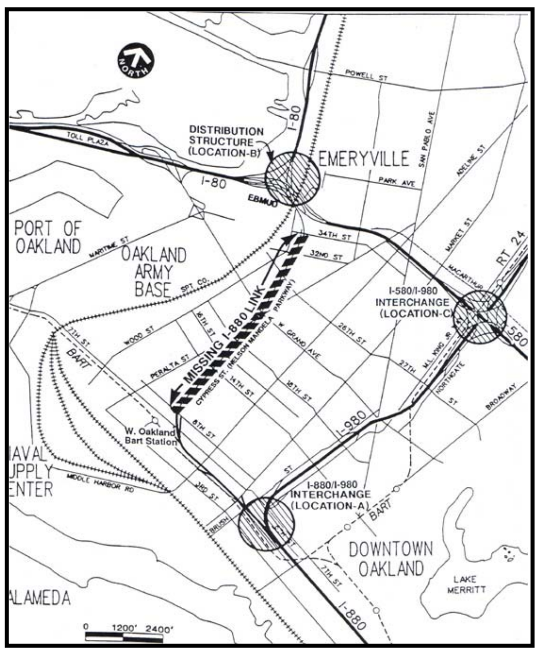
This chapter presents the sixth analysis/quantitative methodological step of the proposed EJ evaluation methodology (EJEM): **What are potential mitigation options?** (see Figure 3.1) First, a detailed review was conducted of two of the 10 cases the Federal Highway Administration (FHWA) identified to exemplify effective mitigation options in urban highway projects. Second, mitigation strategies recommended in the literature to reduce or eliminate the impacts of tolled facilities on EJ communities are presented, including examples to offset the EJ adverse impacts of toll roads in U.S. urban areas. Third, the documented mitigations options are evaluated to determine whether or not they achieved the recommended EJEM given the four defined toll-road scenarios. Potential mitigation strategies to reduce or eliminate the additional ecological, mobility, safety, social and economic impacts of tolled facilities on EJ communities are listed, including specific examples to offset the financial burdens on low-income populations. Fourth, the relevant regulations and definitions contained in the Texas Administrative Code that stipulates the expenditures of toll surplus revenues is provided, followed by a discussion of its suitability to support this methodological component. The chapter ends with concluding remarks.

8.1 EFFECTIVE MITIGATION OPTIONS FOR HIGHWAY PROJECTS

A detailed review was conducted on two of the 10 cases the FHWA identified to exemplify effective practices in promoting EJ principles (Federal Highway Administration, 2000). These study cases are the only two of the 10 cases that represent highway projects in urban areas and useful EJ practices. Although neither of these cases involved a toll road facility, the mitigation options were evaluated to determine whether or not they achieved the proposed methodology for the EJ assessment of tolled facilities.

8.1.1 The Cypress Freeway Replacement Project (Oakland, California)

The Cypress Freeway Replacement Project (California Department of Transportation, 1991) entailed the rebuilding of a section of the I-880 freeway, known as the "Cypress Structure", which collapsed during the October 17, 1989 Loma Prieta earthquake (Figure 8.1).



Source: Adapted from Final Environmental Impact Statement Report FHWA-CA-EIS-90-05-F, Volume 1 (1991)

Figure 8.1 Post-Quake Freeway Network

The damaged section was an important route for local employers in the area and for travelers from West Oakland to and from San Francisco, Berkeley, and the South Bay. Before the earthquake, more than 160,000 vehicles traveled daily on the eight-lane freeway. The project area included the western portion of the city of Oakland and the city of Emeryville - a total of seven neighborhoods. The majority of the West Oakland residents were African Americans (81 percent) while the Emeryville residents were largely Caucasian (64 percent). In 1980 more than 35 percent of the residents in West Oakland were living below the federal poverty level.

During the demolition of the old "Cypress Structure" and the construction of the new structure, the California Department of Transportation (Caltrans) implemented several mitigation actions to lessen the impacts on the Oakland community (California Department of Transportation, 2000). These actions included:

- the temporary relocation of nearby residents and the installation of dust screens on homes in close proximity to the demolition site.
- the encouragement of truck drivers to use designated routes instead of residential streets to and from the Port of Oakland.
- the provision of additional crossing guards at two local schools to ensure the safety of the children.

Mitigation actions for residents and businesses in close proximity to the new freeway included:

- noise barriers to reduce the projected freeway noise levels to between 62 and 67 decibels.
- landscaping in front of the sound barriers, which included densely planted trees and shrubs, to provide an aesthetic visual screening from the freeway to the neighborhoods.
- relocation of 30 houses and 46 businesses whose properties were located within the right-of-way of the preferred alternative.

Despite the above mentioned mitigation actions, a coalition of residents from the Phoenix and Prescott communities filed a lawsuit against Caltrans, the U.S. Department of Transportation, and the FHWA in March 1993 in an effort to prevent the construction of the freeway on the selected alignment. The coalition claimed the agencies violated the National Environmental Policy Act (NEPA) and Title VI of the Civil Rights Act in not fully considering the health and environmental effects of the project on its EJ community. In response, Caltrans agreed to additional mitigation measures, including noise walls, landscaping, and the reimbursement cost for an air conditioning system and the soundproofing of a church located near the freeway.

The project also provided employment opportunities for local residents. In July 1993, Caltrans and the City of Oakland signed an agreement – the Freeway Performance Agreement - to resolve economic concerns that came about during the design and construction of the project (Public Roads, 2004). At the time of the project, Oakland residents held only 12 percent of the jobs generated by the major local industries. For many years, residents in the area argued that they suffer negative environmental and traffic impacts generated by local employers and the Oakland freeway network while not receiving any significant share of the economic benefits. The Freeway Performance Agreement included provisions to ensure local residents and businesses received a proportionate share of the jobs and contracts generated by the project. In addition, Caltrans continues to fund a construction job training program, which was created to increase employment opportunities for Oakland residents.

8.1.2 The East-West Expressway Environmental Impact Statement (Durham, North Carolina)

In 1959, planning for the East-West Expressway was initiated with the highway's inclusion in the transportation plan of the North Carolina Department of Transportation (NCDOT) and the city of Durham (North Caroline Department of Transportation, 2000). Construction of the first segment of the highway began in 1967 and by the early 1970s almost half of the expressway was opened. During the 1960s, several urban-renewal programs called for the relocation of older homes and businesses along the proposed East-West Expressway. Haity, a major African-American neighborhood, was practically displaced and the limited relocation benefits offered to the residents resulted in an enduring antipathy and distrust of government agencies among Durham's African-American residents.

Planning for the acquisition of the right-of-way for the construction of the remaining segment of the expressway began in 1973 (North Caroline Department of Transportation, 2000). The purpose of the project was to provide access to large employment centers, such as the Durham central business district, major manufacturers, and the Duke University Medical complex. It was also to address congestion concerns in Durham that were hampering the city growth. The foreseen impacts on a small African-American neighborhood, consisting of over 200 households known as Crest Street, were, however, at issue. In essence the proposed project called for the relocation of the neighborhood. The Crest Street neighborhood opposed the project, firstly because most of the residents were employed within a mile of their residences at Duke University and the Duke University Medical Center, and secondly to preserve community cohesiveness. In 1973, ECOS[14], an alliance of the Crest Street neighborhood, achieved an important court decision that required the North Carolina Department of Transportation (NCDOT) and the FHWA to prepare an Environmental Impact Statement (EIS) which complied with NEPA. During the EIS process, sociological surveys provided a meaningful statistical picture of the cohesiveness of the impacted community (see Table 8.1).

[14] ECOS, a Duke University group, was against the expressway for environmental reasons.

Table 8.1 Indicators of the Cohesiveness of the Crest Street Community

Measure	Value
Length of Tenure for Residents	
Average length of residence in the community	36.5 years
Average length of tenure for tenants	10 years
Residents whose tenure exceeded 50 years	30 %
Kinship in the Community	
Residents with at least one relative in the community	65 %
Residents with five or more relatives in the community	55 percent
Degree of Job Stability	
Average length of employment at job	more than 8 years
Local Employment	
Workforce working within a mile of the community	44.3 %
Perception of Physical Safety	
Considered the neighborhood safe	90 %
Complaints about community's minors	none
Other: Social Support Systems	
Residents provided child-care and transportation to one another, cooperated during times of need, and participated freely in neighborhood improvement activities, such as periodic community clean-up days	-----

In 1982, the Final EIS was completed. It included the final mitigation (see Section A.2.3) and enhancement a plan agreed to by all the parties. A comprehensive mitigation and enhancement plan was developed by leaders from the Crest Street neighborhood together with a committed group of professionals from FHWA, NCDOT, the City of Durham, Duke University, and the U.S. Department of Housing and Urban Development in an effort to preserve the cohesiveness of the Crest Street neighborhood (North Caroline Department of Transportation, 2000). The plan provides an excellent example of how a transportation project can be planned, designed, and constructed to preserve community cohesion while at the same time respond to the demand for a transportation network that supports the economic growth of a region. The comprehensive mitigation and enhancement plan included the following measures:

- the movement of over 1,000 graves to provide a community site near the previous site, which minimized disruption in people's lives and avoided adverse impacts for those who walked to their jobs.
- the realignment of an expressway interchange to maximize the land available to the new community.
- the relocation of 65 houses from the old neighborhood to a new location and the renovation of these houses with new interiors and modern conveniences.
- the renovation of 12 existing housing units with entirely new interiors and modern conveniences.
- the construction of 178 new housing units (i.e., 112 single-family and 66 multi-family) to replace the displaced housing units in the highway footprint, as a way of preserving the social interaction among members of the Crest Street neighborhood.
- the conversion of a former school building into elderly housing.
- the renovation of the existing houses on the new site.
- the construction of apartments for those who could not afford to purchase a home.
- "stacked" relocation benefits and housing assistance programs to maximize home-ownership.
- the provision of subsides, including the relocation of homes at salvage value, the payment of moving costs, city rehabilitation grants, and deferred second mortgages, to maximize home-ownership. Before the project 22 percent of the households in the Crest Street neighborhood owned their homes. At project completion, 56 percent of Crest Street's households were homeowners.

- the provision of modern infrastructure at the new community location, including streets, sidewalks, sanitary and storm sewers, and street lighting.
- the construction of two new parks and a community center.

To make the proposed mitigation and enhancement plan a reality, the State of North Carolina enacted legislation commensurate with the Federal "housing-of-last-resort" provision of the Uniform Relocation and Real Property Acquisition Policies Act of 1970. The housing-of-last-resort provision provided the FHWA with flexibility to commit federal funds to construct replacement dwellings for the new community. The state enacted legislation allowed the state to match funds for the replacement of housing units.

8.2 MITIGATION STRATEGIES PERTAINED TO TOLLED FACILITIES

Mitigation strategies recommended in the literature to reduce or eliminate the impacts of tolled facilities on EJ communities include the following:

- use of toll revenue to finance transportation improvements, such as new or expanded transit services that benefit low-income travelers (DeCorla-Souza and Skaer, 2003).
- provision of toll exemptions to low-income travelers, increasing the quantity and quality of low-cost transportation alternatives, and returning some of the toll revenue to low-income households in the form of reduced regressive taxes and improved social services (Litman, 2004).
- reduction of general taxes or other user fees and redistributing toll revenues according to income (i.e., lowest-income individuals receive the largest compensation) (Lee, 2003).
- returning road charges to each group through cash rebates in proportion to the amount the group pays (Litman, 1999).

- realignment of the toll road.

Mitigation options to offset the adverse impacts of toll road facilities in U.S. urban areas are also documented in the literature. For instance a toll road project in Houston, Texas, threatens access of an elderly Chinese community to a popular Chinese cultural center (Houston Chronicle, 2004a). Elderly Chinese living south of the cultural center were in the habit of traveling north by foot or bike along a road that ran north-south toward the center. The proposed east-west toll road would split this road at a point between the community's residences and the cultural center. In response to this public concern, the planners studied options to realign the pertinent section of the toll road under or over the utilized north-south road. Another example is the free access for buses to the high-occupancy toll (HOT) lanes on the Katy Freeway also in Houston (Houston Chronicle, 2004b). Directly addressing the impact of toll roads on local transit users might include free access for buses to the HOT lanes. Failure to consider this alternative when mitigating the EJ impacts of toll road projects might be a basis for EJ community complaint, especially if the added cost of transit is passed on to rider for use of toll facilities. In San Francisco's Bay Bridge, a "lifetime" toll rate of $1 is offered to low-income drivers who can prove that their household income is at or below 150 percent of the federal poverty level (Yee, 1995). Finally, support for use of toll revenue for transit improvements is strong in some metropolitan areas such as in New York. There the local automobile club supports the use of toll revenue for transit based on the understanding that more people riding in public transportation results in less congestion for motorist (DeCorla-Souza and Skaer, 2003).

8.3 WHAT ARE THE POTENTIAL MITIGATION OPTIONS?

Step 6 of the EJEM aims to identify actions to mitigate or offset identified disproportionately high and adverse impacts imposed by a toll road on EJ populations given the four defined toll-road scenarios. Mitigation or enhancement measures comprise of (1) avoiding or minimizing impacts by reducing the degree or magnitude of the implemented action, (2) mitigating or eliminating the impact by repairing, rehabilitating, or restoring the affected environment or community resource, (3) reducing or eliminating the impact over time by long-term preservation and maintenance operations, and (4) compensating for the impact incurred. Table 8.2 lists a number of mitigation strategies to reduce or eliminate the additional social, economic, and environmental impacts of tolled facilities on EJ communities. This table can be used by the transportation agency as a guideline since applicable mitigation options should be examined on a project-by-project basis.

Table 8.2 Actions to Mitigate or Offset the Burdens Imposed by Toll Road Projects on EJ Communities

Physical Environmental Quality Impacts	
Air pollution (health effects)	Realignment of the toll road to protect neighborhoods adjacent to the facility from polluted air
	"Buffer zones" to protect vulnerable populations (e.g., children playing outdoor) and sites (e.g., schools and hospitals)
	Relocation of the affected receptors (e.g. housing units, office buildings, schools, hospitals, and nursing homes)
	Ban heavy vehicles from neighborhood streets
	Truck-only toll lanes
	Travel demand management (TDM) strategies to reduce air pollutants (e.g., traffic signal coordination at frontage roads, ridesharing promotion through toll exemptions to transit and carpoolers)
	Cleaner fuel for construction equipment (e.g., ultra-low sulfur diesel)
Traffic noise	Realignment of the toll road to protect neighborhoods adjacent to the facility from polluted noise
	Relocation of the affected receivers (e.g., housing units, office buildings, schools, hospitals, and nursing homes)
	Noise barriers (constructed from concrete block, masonry blocks, steel, aluminum, or wood)
	Noise berms (constructed from natural earthen materials such as soil, stone, rock, or ruble)
	Soundproofing systems at sensitive sites (e.g., schools, churches, child care centers, and hospitals)
	Quiet pavement (e.g., dense-graded asphalt, open-graded asphalt)
Mobility and Safety Impacts	
Access to work, shopping, sensitive sites (health care centers and educational facilities), and recreational places	Toll exemptions to low-income travelers, carpoolers, and transit
	Improvements to existing non-toll roads
	Operational improvements to arterials and frontage roads (e.g., coordinated traffic signals)
	Improvements to public transit that benefit low-income travelers (e.g., new or expanded transit services, bus stops within a 1/4 mile radius, availability of bus shelters)
	Relocation of public facilities (e.g., schools, hospitals, and playgrounds)
	Improvement to non-motorized transportation modes (e.g., sidewalks and bikeways)
	Improvements to walk-transit linkages/bike-transit linkages/park-and-ride facilities
	Housing relocation sites accessible by primary neighborhood transportation mode
Bicycle use	New or expanded bikeways
	Improvements to bikeway crossing opportunities
Pedestrian use	Improvements to pedestrian signals, signs, and pavement markings
	Improvements to sidewalks and pedestrian crossing opportunities
	Traffic calming devices (e.g., speed bumps, roundabouts, street closures, restricted access, and brick paving) to reduce vehicle speeds and vehicle dominance, and to control the behavior of the remaining drivers
	Crossing guards at local schools during project construction

Table 8.2 Actions to Mitigate or Offset the Burdens Imposed by Toll Road Projects on EJ Communities

Social and Economic Impacts	
Displacement of residential properties	Fair relocation benefits to (temporary/permanent) displaced residents
	New/better housing units for displaced residents
	Improvements to public areas at the relocation site (e.g., sidewalks, bikeways, parks, and playgrounds)
	Improvements to public services at the relocation site (e.g., health care centers, schools, and community centers)
	Housing relocation site accessible by primary neighborhood transportation mode
Neighborhood cohesion, social interaction	Relocation of the entire community
	Relocation of all relatives
	Relocation of areas of unique significance (e.g., cemeteries)
	Renovation of housing units remaining in the impacted area
	Construction/renovation of public areas (e.g., sidewalks, bikeways, parks and community centers)
	Realignment of the toll road to maximize the land available to community public space (e.g., parks and community centers)
	Realignment of the toll road to preserve sacred sites and places of historic and cultural significance
Neighborhood traffic patterns and safety	Ban heavy vehicles from neighborhood streets
	Traffic calming devices (e.g., speed bumps, roundabouts, street closures, restricted access, brick paving) to reduce vehicle speeds and vehicle dominance, and to control the behavior of the remaining drivers
	Improvements to traffic signals, traffic signs, pavement markings, and lighting
	Improvements to sidewalks, bikeways, and pedestrian crossing opportunities
	Provide crossing guards at local schools during project construction
Displacement of local businesses	Fair relocation benefits to displaced businesses
	Maintain/enhance access to displaced businesses at the relocation site (e.g., improvements to traffic signals, traffic signs, pavement markings, sidewalks, and lighting)
Local employment/job creation	Fair share of contracts generated by the project earmarked for local businesses
	Fair employment opportunities for local residents during construction phase
Business access and deliveries	Maintain/enhance access to displaced businesses at the relocation site (e.g., improvements to traffic signals, traffic signs, pavement markings, sidewalks, and lighting)
Income/Financial household	Variable toll rate based on household income
	Enhance transportation alternatives for peak-period travelers (e.g., toll refunds/exemptions for low-income travelers, free toll to high-occupancy vehicles)
	Use the revenue generated by the toll road to finance transit investments and non-toll roads improvements
	Return surplus toll revenues to travelers according to household income (i.e., lowest-income travelers receive the largest compensation)
	Use the revenue generated by the toll road to improve non-transport government services (e.g., health and education services) on corridors affected by pricing that benefit EJ communities

Table 8.3 provides examples of the recommended measures to mitigate or offset the additional impacts toll roads could have on the finances of low-income populations.

Table 8.3 Actions to Mitigate or Offset the Burdens Imposed by Toll Projects on Low-Income Populations

Mitigation Options	Example
Toll pricing structure	Variable toll rate based on household income/number of passengers in the vehicle
	Free toll to high-occupancy vehicles (HOV) such as transit and carpoolers
	Toll tags available for purchase with cash and no sign-up or monthly service fee required
	Available cash toll booths
Enhancement of transportation alternatives for peak-period travelers	Reduced toll rates based on federal poverty program eligibility
	Toll credits earned by travelers in congested non-toll lanes that may be used to pay highway tolls or other priced transportation goods such as transit or parking. Low-income travelers could be given credits at a higher rate than that provided for middle and upper income travelers
	Free toll for transit and carpoolers
	Improve transportation services designed to transport welfare recipients and low-income individuals to and from jobs and activities related to their employment (e.g., transit vouchers for welfare recipients and low-income individuals)
Use the revenue generated by the toll road to finance transportation improvements	Improve the overall mobility alternatives for the entire transportation system, not just for automobile users
	New or expanded transit services and biking/walking facilities - especially on corridors priced or affected by pricing- that benefit EJ communities
	Decreased transit fares by toll subsidy
	Adequate pedestrian infrastructure along and crossing the toll facility where there is a reasonable expectation of pedestrian traffic
Return surplus toll revenues to travelers according to household income (i.e., lowest-income travelers receive the largest compensation)	Toll credits/exemptions for low-income travelers
	Cash rebates for low-income travelers
	Reduce general taxes or other user fees
	Surplus invested in improved transit/discount transit fares that benefit EJ communities

Overall, low-income population can be divided into low-income drivers and non--drivers (Litman, 1999). Vehicle expenses significantly affect travel decisions of low-income drivers. In general, toll roads will burden low-income drivers if few or no alternatives exist to satisfy their transportation needs (e.g. alternative non-toll roads or public transit services for trip to work). In this case, low-income households would spend more in transportation compared to higher income households. Because road pricing might toll off low-income populations, they deserve a share of toll revenues in compensation (e.g., by using toll revenues to improve the existing non-toll transportation system, especially on corridors priced or affected by pricing).

Non-drivers usually pay little in road pricing compared to other population groups since they ride as passengers, ride the bus, or use bike and pedestrian facilities to satisfy their transportation needs. Low-income workers, who do not drive, however, spend a larger share of their incomes commuting to work. Since non-drivers depend highly on public transportation and non-motorized transportation modes, use of toll revenues to improve transit/bike/pedestrian infrastructure and services seem justified when a toll road project has a negative impact on the primary transportation modes of EJ populations (for more details see *Toll Road Impact Matrix*).

One particularly promising EJ mitigation option lies in the use of variable toll rates, including tolling technology. For example, high-occupancy toll (HOT) lanes would be free to high-occupancy vehicles (HOV), while single-occupant vehicles (SOV) would have to pay a toll. This measure may be a strong counterargument to allegations that toll lanes by definition exclude low-income travelers because HOT lanes would offer EJ carpoolers or transit users the time savings offered by any other toll lane, without the expense. Electronic toll tags that require sign-up, credit cards, high cost to enroll (including deposit, prepaid amount, monthly service fees, and automatic recharge) are more likely to burden EJ populations. Toll tags widely available for purchase with cash and no high cost to enroll, and cash booth tolls will benefit low-income travelers when driving on toll roads.

The revenue generated by toll road projects (after bond payment) might be used to mitigate the perceived inequity by financing transportation improvements such as new or expanded transit, pedestrian, or bicycle infrastructure and services that benefit low-income travelers, improving the connectivity and safety of existing non-toll roads, and offsetting the need for transportation by promoting mixed land use (e.g., high density housing near public transit stops, pedestrian-friendly neighborhoods and shopping areas near transit facilities). For example, in San Diego, California, all surplus revenues from the I-15 HOT lane are used to finance new bus services which provide better choices for transit users and carpoolers to suburban jobs while reducing road congestion (Environmental Defense, 2003). Toll revenues from the Hudson River bridges and tunnels and Staten Island bridges support better PATH transit and regional transportation infrastructure and services (Environmental Defense, 2002).

Toll revenues might also be used to provide toll and transit fare credits to low-income drivers. As in the FAIR lane concept[15] (DeCorla-Souza and Skaer, 2003), all drivers may be given a credit to use non-toll lanes during congested periods. These credits can be used to pay for transit fares, parking fees, or highway tolls. Because toll roads might take a larger share of low-income family incomes compared to high-income family incomes, low-income travelers could be provided with credits at a higher rate - based on federal poverty program eligibility- than that provided for middle and upper income travelers. In spite of the advantages of providing monetary reimbursement to individuals as a mechanism to address the potential inequity of toll road facilities, a survey of road pricing programs worldwide did not reveal any cases where toll revenues

[15] FAIR lanes or "Fast and Interviewed Regular Lanes" involves separating freeway lanes into two sections: "fast" lanes and "regular" lanes. The fast lanes would be electronically tolled express lanes. In the regular lanes, drivers with transponders would be compensated because of constrained flow.

are being used to provide transit fare credits or any kind of refunds to individuals (U.S. Department of Transportation, 2005).

8.4 TEXAS STATUTE

Texas law prescribes that the toll revenue collected from the operation of a converted segment of an existing non-toll (i.e., Scenario 1) may only be used to finance the improvement, extension, expansion, or operation of the tolled segment of the highway (Texas Administrative Code, 2004b) .

Each fiscal year, if a Regional Mobility Authority (RMA) determines it has **surplus revenue** from transportation projects, the RMA shall (1) reduce tolls, (2) deposit the surplus revenue to the credit of the Texas Mobility Fund, or (3) spend the surplus revenue on other tolled or non-tolled **transportation projects** in the region. Box 8.1 shows the relevant regulations and definitions contained in the Texas Administrative Code that stipulate the expenditures of surplus revenues on transportation projects.

If an RMA develops a toll road, selling bonds and using the toll collected to pay off the debt can finance it. After the toll road is paid for, the toll revenue can be used to finance other local transportation projects. Although RMAs can use the surplus revenue to finance other transportation projects needed in the region (after bond payment), the emphasis on capital construction (see Box 8.1) suggests that is unlikely to fund some types of alternative transportation expenditures such as new or expanded public transit or improvement to the existing non-toll roads, including the local roads. Local roads are important in mitigating EJ concerns because minority and low-income populations are likely to use them, and their performance would have an impact on travel costs for these populations groups. Surplus revenue, however, can be used to finance pedestrian and bicycle projects as well as air quality improvement projects. It seems travel demand management (TDM) strategies aims to improve air quality (e.g., traffic signal coordination at frontage roads, ridesharing promotion through toll exemptions to transit and carpoolers) might be funded by toll revenues.

Box 8.1 Uses for Surplus Revenues

An RMA may spend **surplus revenue** in the region on other **transportation projec**t (Title 43, Texas Administrative Code, Section 26.53) by:

- constructing a transportation project located within the counties of the RMA;
- assisting in the financing of a toll or toll-free transportation project of another governmental entity; or
- constructing a toll or toll-free transportation project and, on completion of the project, transferring the project to a governmental entity

Definitions (Title 43, Texas Administrative Code, Section 26.2)

Surplus revenue– Revenue that exceeds:

(a) the regional mobility authority's debt service requirements for a transportation project, including the redemption or purchase price of bonds subject to redemption or purchase as provided in the applicable bind proceedings;

(b) coverage requirements of a bond indenture for a transportation project;

(c) cost of operation and maintenance for a transportation project;

(d) cost of repair, expansion, or improvement of a transportation project;

(e) funds allocated for feasibility studies; and

(f) necessary reserves as determined by the regional mobility authority

Transportation project means:

(a) a turnpike project;

(b) a system designated under Transportation Code, Section 379.034;

(c) a passenger or freight rail facility, including: tracts, a rail line; switching, signaling, or other operating equipment; a depot; a locomotive; rolling stock; a maintenance facility; and other real and personal property associated with a rail operation;

(d) a roadway with a functional classification greater than a local road or rural minor collector;

(e) a ferry;

(f) an airport;

(g) **a pedestrian or bicycle facility**;

(h) an intermodal hub;

(i) an automated conveyor belt for the movement of freight;

(j) a border crossing inspection station;

(k) **an air quality improvement initiative**;

(l) a public utility facility; and

(m) if applicable, projects and programs listed in the most recently approved state implementation plan for the area covered by the RMA, including an early action compact.

Finally, Title 23 U.S.C., as amended by the Safe, Accountable, Flexible and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) (Public Law 109-59, 2005), permits a state to use excess toll revenues, called transportation development credits, for developing alternatives to SOV travel and projects for improving highway safety. In this regard, the Texas Transportation Commission in its meeting held on December 15, 2005, in Austin, Texas, supported the use of transportation development credits to finance transit systems that meet Texan's transportation needs (Texas Transportation Commission, 2005).

8.5 CONCLUDING REMARKS

Mitigation plans are crucial in offsetting the adverse impact of a toll road project on EJ communities. Hypothetical mitigation packages to reduce or eliminate the additional social, economic, and environmental burdens a toll road project may impose on minority and low-income populations given the studied toll scenarios include (a) toll credits/toll exemptions/cash rebates for low-income travelers, (b) free toll lanes for transit and carpoolers, (c) new or expanded transit, pedestrian, and bicycle infrastructure and services that benefit EJ populations, (d) improvements to the connectivity and safety of existing non-toll roads especially on corridors priced or affected by pricing, (e) land use and development measures that encourage denser and more pedestrian-friendly neighborhoods, shopping areas and community facilities (e.g., hospitals, libraries) near transit facilities, (f) travel demand management strategies aims to improve air quality and protect human health, (g) relocation/renovation of affected housing units, public spaces, and sacred sites to ensure/protect EJ community cohesion, (h) enhancement to local businesses access, (i) fair share of contracts generated by the project earmarked for local businesses, and (j) noise barriers to mitigate traffic noise pollution on neighborhoods adjacent to the toll plaza. A comprehensive list of mitigation options is provided in Tables 8.2 and 8.3. Recommended mitigation options can be part of the scope of the toll road project and or be financed by surplus revenues.

In Texas, road pricing would increase equity, reduce demand for road expansion, and enhance environmental quality if toll revenues are used to finance primary EJ population travel choices, like paying for better public transit and bike-transit linkages, and the mitigation and remediation of adverse impacts to compensate those affected population groups. The Texas Administrative Code restricts the use of Regional Mobility Authority's surplus revenue to (1) reducing tolls, (2) depositing in the Texas Mobility Fund, or (3) constructing a transportation project, tolled or non-tolled, in a county of the RMA. Also, Texas law prescribes that the toll revenue collected from the operation of a converted segment of an existing non-toll may only be used to finance the improvement, extension, expansion, or operation of the tolled segment of the highway. There does not seem to be any mechanism for funding either transit operations or offering cash rebates.

The Texas Transportation Commission supports the use of excess toll revenues (i.e., transportation development credits) to finance transit systems that meet transportation needs of Texas (Texas Transportation Commission, 2005). Texas statute, however, presents a number of institutional challenges that have to be fully overcome before the RMA's surplus revenue can be used to upgrade current transit services (e.g., increase frequency service), provide new transit services (e.g., new transit routes), improve existing non-toll roads, or provide monetary reimbursement to individuals.

Potential financial effects of toll road projects on low-income travelers will be considered as part of the EJ assessment of toll transportation facilities. When such effects are expected to impact EJ populations disproportionately compared to other population groups, options to offset the identified burdens should be evaluated and a comprehensive mitigation and enhancement plan should be designed as part of the environmental studies. The cost of such mitigation measures might be included as part of the toll road project implementation cost. Because toll road projects must produce sufficient revenue to pay back the bond holders with interest, any action that might affect a toll road's ability to repay its debt requires special scrutiny. Many of the proposed mitigation options for toll roads could add significant cost and uncertainty to a project. As the same time, the state is committed to fulfill the requirements for EJ analysis of toll road projects. How EJ concerns can be mitigated without creating risk for the bondholders is a question that might be the subject of a future research.

Chapter 9 Basis of the Effective EJ Participation Component

This chapter presents the basis for the development of the environmental justice (EJ) participation components of the proposed EJ evaluation methodology (EJEM). First, strategies for effective public participation by EJ communities in highway projects in urban areas are presented. Second, the salient findings of a *Telephone Survey* and a *Door-to-Door Survey* conducted between January and April of 2006 in the potentially impacted areas of toll road projects planned for Central Texas are presented. Third, a methodology to identify strategic locations for interacting with the EJ communities is conceptualized and applied using data gathered from the potentially impacted area by the new toll road systems planned for Central Texas. The insights gained from the study cases, the surveys, and the role of Geographic Information Systems (GIS) and spatial analysis in strengthening EJ public participation are used to define the general approach to ensure meaningful participation in each step of the EJEM (Chapter 10) and the specific goals of the EJ outreach effort during each stage of the EJEM (Chapter 11). The chapter ends with concluding remarks.

9.1 Effective Public Involvement for Highway Projects

This section highlights two of 10 cases identified by the Federal Highway Administration (FHWA) which exemplify effective practices in promoting Environmental Justice (EJ) principles (Federal Highway Administration, 2000). The two study cases are the only cases which represent highway projects in urban areas and useful EJ practices in different stages (project development, right-of-way evaluation, community impact assessment, and public involvement). Although neither of these cases involved a toll road facility, the communication techniques with EJ communities were evaluated to determine whether they could be included in the EJ evaluation methodology (EJEM) for tolled facilities.

9.1.1 The Cypress Freeway Replacement Project (Oakland, California)

The Cypress Freeway Replacement Project (California Department of Transportation, 1991) consisted of the rebuilding of a section of the I-880 freeway, known as the “Cypress Structure”, which collapsed during the October 17, 1989 Loma Prieta earthquake (for more details see Chapter 8). This case study provides an example of how the California Department of Transportation (Caltrans) attempted to engage the affected communities in the various stages of the rebuilding of the Cypress Freeway in Oakland through community outreach efforts (California Department of Transportation, 2000).

In September 1991, the California Department of Transportation (Caltrans) released the Final Environmental Impact Statement (FEIS), which included six studied alternatives and a preferred alignment for the new freeway. The alternatives included a no-build alternative option, two alternatives utilizing the existing Cypress right-of-way, and three versions of the railroad corridor alignment advocated by the Citizens Emergency Relief Team[16] (CERT) and the Cypress Corridor Council.[17] In the beginning of the environmental process, Caltrans argued in favor of reconstructing the “Cypress

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[16] The Citizens Emergency Relief Team (CERT) - a West Oakland citizen’s group - organized to represent the West Oakland community (Phoenix and Prescott Neighborhood Associations) in the reconstruction of the Cypress Freeway and other rebuilding efforts following the Loma Prieta earthquake.

[17] The Cypress Corridor Council was assembled to provide a forum for articulating and responding to community and regional concerns by involving a broad base of constituencies and views. This Council was comprised of 40 to 50 members representing politicians, agencies, organizations, and groups. The Cypress Corridor Council formed a Transit Subcommittee that formulated the Transit/TMS/Freeway base alternatives. The subcommittee consisted of representatives from BART, RIDES, and AC Transit, ferry operators from Alameda and San Francisco, the Port of Oakland, the Sierra Club, FHWA, MTC, and Caltrans.

Structure" using the existing right-of-way, because it was the least expensive and most convenient solution. CERT and the Cypress Corridor Council, however, made it clear to Caltrans that this solution would not meet the needs and concerns of West Oakland residents. The impacted community argued for an alternative that would reunite the community that had been split when the Cypress Structure was originally built in the 1950s (California Department of Transportation, 2000). Air pollution generated by (a) the Port of Oakland, (b) major freeways, (c) truck traffic, and (d) neighborhood industrial facilities were also of concern to both the West Oakland and Alameda county communities. These residents argued that car exhaust fumes contributed to higher incidents of underweight babies, infant deaths, and acute and chronic diseases. The latter concerns were important in solidifying the community's opposition to the rebuilding of the Cypress Freeway using the existing right-of-way and to Caltrans rethinking its preferred alternative.

Caltrans decided to consider the desires and needs of the West Oakland residents. The resulting project was more expensive and time consuming, but it accommodated the needs of the impacted communities. The selected alternative runs west of the previous "Cypress Structure", closer in proximity to the Port of Oakland, following the Southern Pacific railroad tracks for a portion of the way before deviating from the railroad's course. The selected alternative does impact a small residential area (i.e., Phoenix and Prescott communities), but the majority of West Oakland would be reunited under the plan. In October 1991, the Caltrans Transportation Commission approved the FEIS. Public participation continued to play an important role during the project design, which in the end generated additional benefits to the community.

During the project design and construction phases, negotiations between Caltrans and the City of Oakland and West Oakland community groups led to a number of additional area benefits and two significant changes to the project design (California Department of Transportation, 2000). First, Caltrans agreed to build an off-ramp from the new freeway to serve the Port of Oakland directly so that heavy trucks traveling to and from the port would no longer use residential streets. The second concession involved the continued use of an existing off-ramp. West Oakland businesses owners were concerned that the removal of the ramp would limit access to their businesses. A West Oakland resident and member of CERT thus prepared and presented a design proposal to Caltrans in which the ramp was kept. Caltrans agreed to modify the structure based on the submitted design proposal. Freeway construction began in January 1994 and was completed in September 1998.

In developing and considering the alternatives, Caltrans consulted a wide range of groups, including local, regional, state, and federal jurisdictional agencies, the local business community, citizen's and environmental groups (e.g., CERT, the Cypress Corridor Council, Oakland Citizens Committee for Urban Renewal), and major local employers (e.g., the Port of Oakland, the U.S. Army and Navy Installations, and the U.S. Postal Service Distribution Facility). Caltrans held public meetings, open houses, workshops, and made presentations (see Table 9.1) to involve public officials and citizens and to keep them informed of proposed actions. The outreach efforts involved various sectors of the community and several multimedia channels were used to communicate the proposed plan.

Table 9.1 The Cypress Freeway Replacement Project - Community Outreach

Date	Action
October 17, 1989	**The Loma Prieta earthquake strikes the Bay Area, causing the collapse of the Cypress Freeway**
February 1990	Notice of preparation to responsible agencies
February 13, 1990	A Notice of Intent published in the Federal Register
February 28, 1990	A public scoping meeting held at the Lowell Middle School to announce the beginning of environmental studies and to receive input on the scope of these studies
Undated	Presentation to the Oakland City Council regarding project alternatives
November 1989	*Newsletter 1* and *Newsletter 2* distributed; highlighted rescue efforts, interim plans, and provided details about the information center
December 1989	*Newsletter 3* and *Newsletter 4* distributed; contained employment and business opportunities, news of Cypress Street repair, removal activities and seismic testing
January 1990	*Newsletter 5* distributed; contained a notice for upcoming public information meetings
February 1990	*Newsletter 6* distributed; contained and discussed further public meetings and replacement options
May 1990	*Newsletter 7* distributed; contained community involvement information, updates on engineering and environmental studies, replacement alternatives, transit, and historic preservation efforts.
November 1990	**Caltrans releases the Draft EIS**
December 1990	*Newsletter 8* distributed; contained and discussed availability of the Draft EIS, upcoming public open houses and public hearings, alternatives under consideration, and a timeline schedule of the circulation of the DEIS until the end of construction (1996)
January 7, 1991	Open house held at Lowell Middle School
January 8, 1991	Open house held at Prescott Elementary School
January 9, 1991	Caltrans' Public Hearing on the Draft EIS held at McClymonds High School Approximately 250 people attended; 47 citizens spoke and 140 persons submitted comments on cards. The official comment period ended February 1, 1991. Written comments, however, were received until early March of 1991. Seventy comment letters were received by Caltrans within the 45 day comment period. These letters were written by local, state, and federal agencies, businesses, organizations, and citizens.
Undated	**Meetings/Presentations, Workshops, and a Forum since the Public Hearing**
Community organizations and property owners	Numerous meetings were held with the Citizens Emergency Relief Team (CERT) Various housing property owners
Planning, city and transit agencies, and local employers	Numerous meetings were held with the following organizations: Metropolitan Transportation Commission (MTC) The City of Oakland/The City of Emeryville Alameda elected officials and staff The Oakland Chamber of Commerce/ The Emeryville Chamber of Commerce The West Oakland Commerce Association AC Transit/BART East Bay Municipal Utility District The Oakland Army Base/ The Port of Oakland/ The Southern Pacific Railroad Berkeley-Emeryville Trade Show The Emeryville property owners /Various Business owners
Workshop	An urban design workshop was held. Attending city departments, community members, and consultants (1) provided a link between Caltrans' planning and design of the freeway replacement project and community planning efforts underway in West Oakland, and (2) helped to focus the socio-economic and urban design studies.
September 1991	**Caltrans releases the Final EIS**

Caltrans was proactive in its community outreach efforts and attempted to engage the affected community in the various stages of the rebuilding process. The agency held meetings and made presentations in the early planning stages of the project in locations familiar to affected communities. This has proven to be very successful in engaging residents of a community who normally do not participate in formal public meetings concerning transportation issues that impact their community (ICF Consulting, 2003). Caltrans also communicated extensively with many sectors within the Oakland and Emeryville communities throughout the National Environmental Policy Act (NEPA) process. Finally, the Cypress Corridor Council brought Caltrans staff together with representatives from other agencies and groups. This created an effective forum in which community and regional concerns could be articulated.

To disseminate project information, Caltrans used several channels to keep the public informed (California Department of Transportation, 2000). Meeting information was published in area newspapers. The Draft EIS was mailed to interested parties (stakeholders) and made available to the general public at public offices and libraries. At various stages of the environmental process (from November 1989 to December 1990), eight newsletters were mailed to approximately 10,000 people and/or organizations. Caltrans continued to keep the public informed after the Final EIS was approved in October 1991. In 1992 the agency opened a Public Information Office in the West Oakland historic Glove Building in an effort to answer community questions relating to the project and to keep the public informed of any opportunities and/or disruptions. According to Caltrans, 10,000 people visited the office in the first three years after it opened. In addition, office staff made between 30 and 40 presentations per year to local, regional, and statewide groups. Caltrans also produced 29 issues of a quarterly newsletter, the Cypress Link, which was distributed to more than 15,000 residents, businesses, community organizations, and public officials. The newsletter provided the community with a wide range of information for the duration of the project, including construction updates and contractor information.

Caltrans' public outreach efforts were effective in reaching many sectors of the community and in addressing their concerns. Caltrans, however, mistakenly assumed that the members of specific organizations were speaking for the entire community of West Oakland. In March 1993, a coalition of residents from the Phoenix and Prescott communities filed a lawsuit against Caltrans, the U.S. Department of Transportation, and the FHWA. It claimed the agencies violated the NEPA and Title VI of the Civil Rights Act by not fully considering the health and the environmental effects of the project on its community. Because communities may not always speak with one voice, a special effort must be made to engage representatives from all neighborhoods affected by a project.

9.1.2 The East-West Expressway Environmental Impact Statement (Durham, North Carolina)

Construction of the first segment of the East-West Expressway in North Caroline began in 1967 and by the early 1970s almost half of the highway was opened. Planning for the acquisition of the right-of-way for the construction of the remaining segment of the expressway began in 1973. The project's purposes were to provide access to large employment centers, such as the Durham central business district, major manufacturers, and the Duke University Medical complex, and address congestion concerns that were hampering the growth of the city of Durham (for more details see Chapter 8).

In 1978, the neighborhood organized under the Crest Street Community Council (CSCC) claimed the North Caroline Department of Transportation (NCDOT) violated the NEPA process and Title VI of the Civil Rights Act which prohibits discrimination on the basis of race, color, or national origin in programs and activities that receive Federal funding. According to the FHWA, this exemplifies the strength of Title VI of the Civil Rights Act and its applicability to transportation projects prior to the enactment of Executive Order 12989 - *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income populations* - in 1994. The complaint included several arguments. The most compelling was that the proposed alignment had a discriminatory impact on the neighborhood since the percentage of African-Americans to be displaced by the proposed action was much higher than the overall percentage of African-Americans in the city (North Caroline Department of Transportation, 2000). This argument and the resulting favorable advisory ruling by the U.S. DOT in 1980 were crucial in convincing the NCDOT, FHWA, and the city of Durham to negotiate with the Crest Street neighborhood. This resulted in a collaborative process for preparing a comprehensive mitigation and enhancement plan for the Crest Street neighborhood.

This case study serves as an outstanding example of how all levels of government (i.e., local, state, and federal) can work together with an affected community to enhance environmental quality (North Caroline Department of Transportation, 2000). Several stakeholder meetings were held and the hostile environment that characterized the beginning of the NEPA process turned into a friendly environment in which participants trusted each other. Meetings were held at convenient locations for the residents of the impacted community. Most of the meetings were held at the New Bethel Baptist Church, which was used regularly for community activities. These meetings were instrumental in formulating the components of the mitigation plan. Two committees were established, each with specific responsibilities. A Task Force composed of CSCC representatives, the principal public agencies, including the FHWA, and private organizations was responsible for the development of the technical studies. Training was provided to key personnel assigned to the task force whom had ample power to negotiate solutions. A steering committee, composed of Task Force members, top government officials, and private interest groups, was responsible for approving the initial action plan, monitoring the technical study, and overseeing the planned relocation process. Finally, the presence of a strong church (the New Bethel Baptist Church) and established community leadership were crucial in the formulation and success of the mitigation plan.

9.1.3 Conclusions and Recommendations

The highlighted FHWA case studies present two examples where the social and economic burdens endured by EJ populations as a result of past transportation projects have turned them into active participants in the NEPA process. These case studies highlight the importance of identifying stakeholder groups and incorporating them early into the planning process. The experience shows that a more educated, active, and engage public can improve the Environmental Impact Assessment (EIA) process and contribute to improved environmental quality. Specifically, a project planned and developed in consultation with the affected population groups will improve the outcomes, which promotes community goodwill and satisfaction. Also, because the EIA process is a form of social interaction, a critical component of the process is the inclusion of all perspectives advocated by the stakeholder groups.

Although the two examples involve non-toll road projects, some of the measures, actions, and strategies can be adopted for inclusion in toll-road projects, because they are equally applicable to the effective identification, evaluation, and mitigation of disproportionately high or adverse impacts on minority and low income communities (see Table 9.2). Specifically, the cases illustrate strategies for effective public participation by EJ communities, as required by NEPA, the U.S. DOT, and the FHWA, to ensure that affected EJ communities have an equal influence in the decision-making process of transportation projects.

Table 9.2 Strategies for the Effective Participation of EJ Populations

Goal	Effective EJ Practice
During project development encourage meaningful public participation early in the process and often. Build trust with the communities by engaging all interested and affected parties throughout project development.	Involve the EJ populations early in the process (e.g., purpose and need for the project, alternatives identification) by holding meetings and workshops, and making presentations early in the planning stages and in locations familiar to the affected communities
	Involve members of the EJ populations in decisions that might affect them and in approvals and implementation
	Treat traditional EJ community knowledge as valuable
	Reach out to the EJ communities by holding meetings at locations convenient to them (i.e., churches, schools, community centers located within the community)
	Keep the public informed
	Provide opportunities for public comment prior to making each decision
	Adapt communication materials to the needs of the EJ population groups
	Recognize that EJ community feelings equal facts
	Use third-party mechanisms when there are arguments over facts

9.2 *TELEPHONE SURVEY*

9.2.1 Survey Design

In January and February of 2006, religious groups, school, and neighborhood associations serving environmental justice (EJ) communities potentially impacted by the proposed toll road system in Central Texas were surveyed by phone. The main objectives of contacting these community-based organizations in Central Texas were to (a) determine the minority and low-income populations served by the organization, (b) establish the existing level of awareness about proposed toll roads, (c) establish whether they thought the proposed toll roads will impact their constituents, (d) determine the organization's willingness to participate and facilitate future EJ community outreach efforts, and (e) identify the outreach activities preferred by the EJ community (e.g., formal meetings, informal meetings, focus groups, telephone surveys, personal interviews, and questionnaires by mail).

The target population were the community-based associations located within the area impacted by the proposed toll roads in Central Texas. The proposed plan includes new tolls (i.e., SH 130, SH 45 North, Loop 1 North, 183A, and SH 45 Southeast) and toll lanes in the median of existing highways (i.e., US 290 East, US 183 South, and SH 71 East). Based on the Final Environmental Impact Statement for SH 130 (U.S. Department of Transportation & Texas Department of Transportation, 2001), it was assumed that a 6-mile wide buffer along the proposed toll road alignments (see Figure 9.1) would cover the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the proposed toll road system.

The contact details for religious groups, school, and neighborhood associations within the impacted area were obtained using Geographic Information Systems (GISs) and the web. This required the following steps: first, zip codes within the impacted area were identified by map overlays. Second, the web was used to compile a contact list of all churches, schools, and neighborhood associations with the identified zip codes. The list contained the organization's name, physical address, telephone and fax numbers, and contact names (if available). Using the compiled physical addresses, the organizations were mapped in GIS. In total, the target population consisted of 494 units broken down into 230 religious groups, 197 schools, and 67 neighborhood associations. Figures 9.2, 9.3, and 9.4 present the three questionnaires used to survey the religious groups, schools, and neighborhood associations, respectively. Although the questionnaires were customized for each type of organization, the questions were essentially the same.

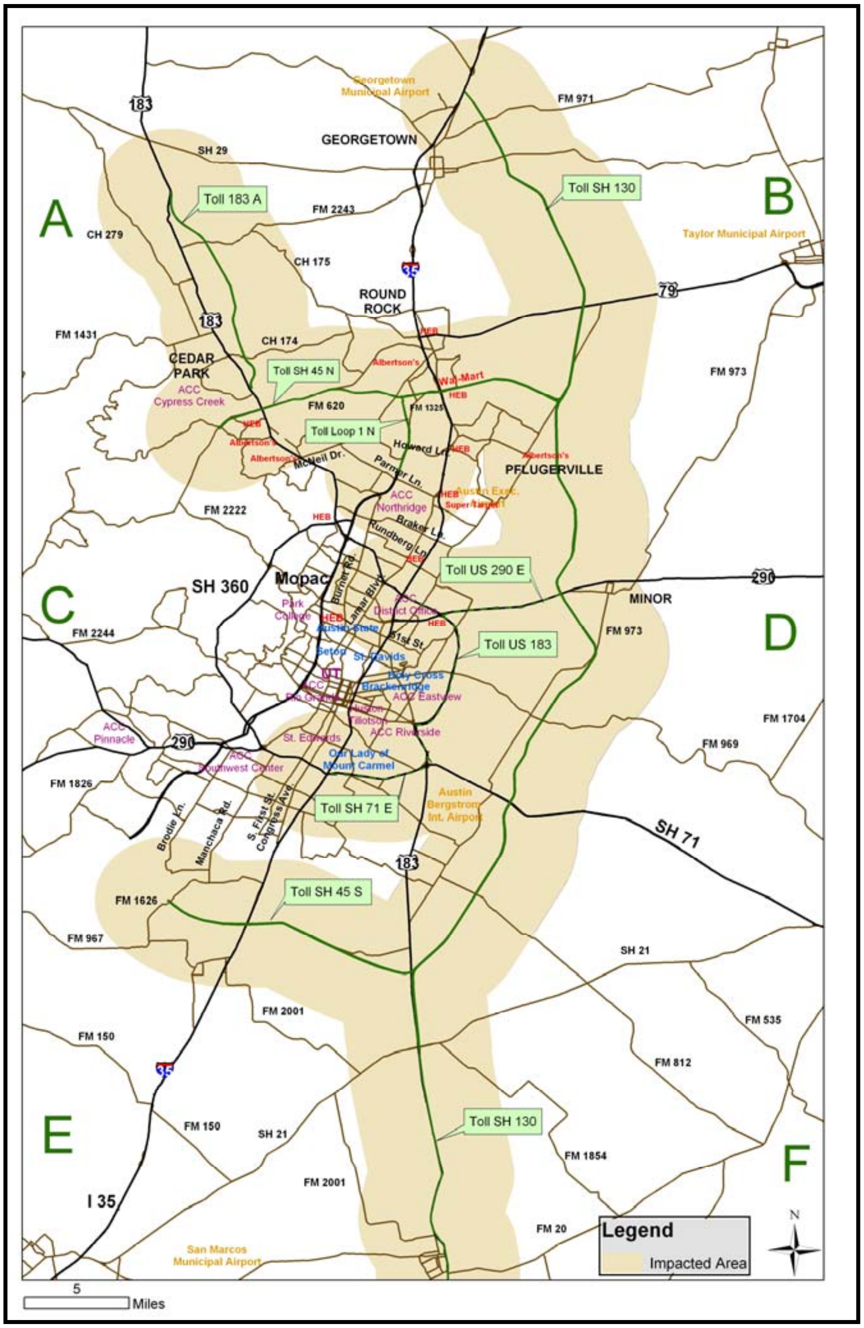

Figure 9.1 Survey Area

Survey Administered to Religious Groups

Interviewer: Good morning/afternoon. My name is ___________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since your congregation can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. Where within the Austin metropolitan area does a majority of your congregation reside? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic location of the religious group that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the congregation boundaries.

2. How many people are in your congregation? _______

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e., American Indian and Alaska Native). Based on this, what percentage in your congregation would you consider minorities? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of your congregation would you consider poor? _________ %

5. How aware do you think your congregation is regarding the proposed toll roads in the City of Austin and surrounding area?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that your congregation will be impacted by the toll roads planned for Central Texas?
   ___ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on the members of your congregation?
   a. If yes, what are the best means for informing your community regarding proposed toll roads? ____

Interviewer : Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact ___________ by email at _______________________________________ or by phone at ______________. Once again, thank you and have a great day.

Figure 9.2 Questionnaire Used for Religious Groups

Survey Administered to Schools

Interviewer: Good morning/afternoon. My name is ________________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since families within your school can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. Where within the Austin metropolitan area does a majority of the families served by your school reside? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic boundaries of the school district that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the school boundaries.

2. How many students are in your school district? __________

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e. American Indian, and Alaska Native). Based on this, what percentage of the families serviced by your school district would you estimate is considered minority? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of the families served by your school district would you consider poor? _________ %

5. How aware do you think families in the school district limits are regarding the proposed toll roads in the City of Austin and surrounding area?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that the families served by your school district will be impacted by the toll roads planned for the City of Austin and surrounding? ___ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on the families served by your school district?
   a. If yes, what are the best means for informing your community regarding proposed toll roads? ____

Interviewer: Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact _____________ by email at ______________________________________ or by phone at ________________. Once again, thank you and have a great day.

Figure 9.2 Questionnaire Used for Schools

Survey Administered to Neighborhood Associations

Interviewer: Good morning/afternoon. My name is ________________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since the members of your neighborhood association can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. What are the geographic boundaries of your neighborhood association? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic boundaries of the neighborhood association that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the neighborhood boundaries.

2. What is the approximate total population within your neighborhood association limits?

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e., American Indian and Alaska Native). Based on this, what percentage of the population within your neighborhood association limits would you consider minority? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of the population within your neighborhood association limits would you consider poor? ________ %

5. How aware do you think the members of your neighborhood association are regarding the proposed toll roads in the City of Austin and surrounding area?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that the members of your neighborhood association will be impacted by the toll roads planned in the city of Austin and surroundings? ____ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on your neighborhood?
   a. If yes, what are the best means for informing your community regarding proposed toll roads?
   ____

Interviewer: Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact _________________ by email at ____ or by phone at _________________. Once again, thank you and have a great day.

Figure 9.4 Questionnaires Used for Neighborhood Associations

Stratified random sampling with proportional allocation was used as the sampling method to ensure that the sample reflected the population with respect to the stratification variable (i.e., type of community-based organization) and that each unit in the sample represented the same number of units in the population. Overall, the pilot survey yielded a 33% effective response rate (5 out of 15 community-based organizations completed the survey) while the main survey yielded a 51% effective response rate (50 out of 98 community-based organizations completed the survey). More details about the survey methodology, pilot survey, response rates, lessons learned, survey results and interpretation, and concluding remarks are presented in Appendix A.

9.2.2 Major Survey Findings

The salient findings from the *Telephone Survey* that helped to structure the EJ public participation component of the proposed EJEM follow.

The overall effective response rate was 51%. Thirteen percent of the sampled unit refused to answer, while over thirty-five percent of the sampled units were not accessible by phone. The response rate of telephone surveys should rarely be less than 80% (Dillman, 1978). A recommended strategy to deal with refusals to participate in telephone surveys is to send an introductory letter in advance of the actual survey-phone call. This would allow the respondents fore-knowledge that they would be called for an interview, reducing the element of surprise (Dillman, 1978; Clarke, et al, 1987), as well as attempts by a second interviewer to convert those who initially refuse to take part (Richardson, et al 1995). Because the validity of the telephone surveys may be threatened by a non-response bias stemming from the refusal to participate, it is recommended to implement similar strategies when surveying by phone community-based organizations in Central Texas . Furthermore, the high number of non-accessible units by phone also suggests that other administration techniques (e.g., in person interviews) need to be explored when surveying community-based organizations in Central Texas.

The response rate of the religious groups contacted was 54%. Of the thirty sampled units, twenty-five agreed to participate while only five declined to complete the survey. An important observation that has to be noted is the fact that a large number of the original sampled religious groups had inaccurate or disconnected telephone numbers. The interviewer thus had to discard sixteen churches that had automated message systems or simply did not answer the phone. A concern is that some smaller churches or churches in extremely poor neighborhoods may not have full or even part-time staff to answer the telephone. It is possible that a survey methodology other than the telephone survey needs to be adopted to contact these churches. Finally, the church respondents were very knowledgeable about their congregations and appeared willing to serve as an avenue to both inform and involve their congregations about planned toll road projects in Central Texas. Most surveyed churches publish a monthly newsletter and offered this as a mean to distribute information to their congregation.

Of the thirty-nine sampled schools, seventeen officials completed the survey and the remaining eight were unwilling to participate, producing a response rate of 44%. It has to be noted that it was extremely hard to get in touch with school officials. They are often in meetings, off-campus, or out of their offices on school grounds, thus requiring repeated call backs. In spite of the modifications to the wording of question 1 (for more details see Appendix A), school officials struggled to identify the geographic boundaries of their schools. Some of the respondents indicated that school boundaries are constantly changing while others noted that the schools do not have set boundaries. On the other hand, school officials were in a position to give a good estimate of the minority families and poor families served by the schools by using the percentage enrollments in their free and reduced lunch program. Finally, although some school officials were willing to participate in community outreach activities by hosting information gathering events, others were concerned about political implications, did not have the space for meetings, were already overburdened with meetings, were worried about the paperwork needed to approve non–school-related meetings, or were simply not interested. Those that were willing to host meetings believed weekday evenings were the best time to conduct such meetings.

Of the thirteen sampled neighborhood associations, eight agreed to complete the survey while the remaining five were unwilling to participate, which resulted in a response rate of 62%. Neighborhood association respondents often struggled to provide the boundaries and population of their neighborhoods. Some, however, could provide the number of families in the neighborhood but not the exact population. Finally, the organization of neighborhood associations varied widely. Some of them rarely meet or keep in contact online, while others meet on a monthly basis and have a website. All respondents, however, were interested in this research and willing to help where and whenever possible.

Religious groups serve 24,712 people, schools serve 12,089 people, and neighborhood associates serve 4,572 people. Religious groups exhibit the greatest variability in terms of minority population served when compared to schools and neighborhood associations (see Table 9.3). Schools exhibit the greatest variability in terms of low-income population served when compared to religious groups and neighborhood associations (see Table 9.3). Because these community-based organizations represent EJ populations, they can serve as "avenues" for informing and involving EJ communities in subsequent EJ community outreach activities.

Table 9.3 Percentage of Minority and Low-Income Populations Represented in the Community-Based Organizations

Minority Population	Religious Groups	Schools	Neighborhood Associations	Total	Percentage*
0 - 25%	11	0	3	14	30%
26 - 50%	6	7	2	15	33%
51 - 75%	2	4	0	6	13%
75 - 100%	2	6	3	11	24%
Total	21	17	8	46	100%
Low-Income Population	**Religious Groups**	**Schools**	**Neighborhood Associations**	**Total**	**Percentage****
0 - 25%	17	7	5	29	67%
26 - 50%	3	4	0	7	16%
51 - 75%	0	4	0	4	9%
75 - 100%	0	2	1	3	7%
Total	20	17	6	43	100%

*Based on 46 valid responses
**Based on 43 valid responses

Overall, only thirty seven percent of the surveyed organizations were very aware regarding the planned toll road system in Central Texas (see Table 9.4). Most members of the religious groups (54%) and the neighborhood associations (37%) were aware of the proposed toll road system whereas schools (12%) were the least aware of the proposed toll facilities.

Table 9.4 Level of Awareness of the Proposed Toll Roads

Level of awareness	Religious Groups		Schools		Neighborhood Associations		Overall	
	Responses	%	Responses	%	Responses	%	Responses	%*
Very aware	13	54	2	12	3	37	18	37
Moderately aware	6	25	3	18	2	25	11	22
Slightly aware	4	17	6	35	1	13	11	22
Unaware	1	4	6	35	2	25	9	19
Total Valid Responses	24	100	17	100	8	100	49	100

*Based on 49 valid responses

Overall, sixty-one percent of the respondents indicated that the proposed toll roads would impact their constituents (see Table 9.5). Most members of the neighborhood association (71%) and the schools (65%) thought the proposed toll road system in Central Texas will impact their constituents compared to members of the religious groups (56%).

Table 9.5 Proposed Toll Roads will Impact the Community

Whether they thought the proposed toll roads will impact their constituents	**Religious Groups**		**Schools**		**Neighborhood Associations**		**Overall**	
	Responses	%	Responses	%	Responses	%	Responses	%*
Yes	14	56	11	65	5	71	30	61
No	11	44	6	35	2	29	19	39
Total Valid Responses	25	100	17	100	7	100	49	100

*Based on 49 valid responses

The Spearman's rank correlation coefficient (r_s) indicates that there is a positive correlation between level of awareness of community-based organizations regarding proposed toll roads and whether they thought the proposed tolled facilities would impact their constituents ($r_s = 0.46$) This finding is statistically significant at the 99% confidence level. The relation between these two variables, however, is not too strong suggesting the need for increased public understanding of how the proposed toll roads may affect minority and low-income populations in Central Texas.

Overall, sixty one percent of the respondents would be interested in participating in community outreach activities (see Table 9.6). The most willing to participate in community outreach activities are the neighborhood associations (86%) followed by the religious groups (68%) and the schools (41%).

Table 9.6 Willingness to Participate in Community Outreach Activities

Willingness to participate in community outreach activities	Religious Groups		Schools		Neighborhood Associations		Overall	
	Responses	%	Responses	%	Responses	%	Responses	%*
Yes	17	68	7	41	6	86	30	61
No	2	8	8	47	1	14	11	23
Unsure	6	24	2	12	1	0	8	16
Total Valid Responses	25	100	17	100	7	100	49	100

*Based on 49 valid responses

From the thirty respondents who think the proposed toll roads will impact their constituents, almost all of them (twenty nine respondents) could list an avenue or method for informing communities about the proposed toll road system in Central Texas. As shown in Table 9.7, respondents indicated that newsletters and meetings to be the two preferred avenues of communication (36% and 27% based on 36 responses). Member of religious groups were able to identify more avenues of communications compared to neighborhood association and school officials.

Table 9.7 Avenues for Informing Communities about Proposed Toll Roads

Avenues of Communication	Religious Groups	Schools	Neighborhood Association	Overall	
	Responses	Responses	Responses	Responses	%
Weekly/Monthly Newsletters	11	---	2	13	36
Church Bulletin Inserts	7	---	---	7	19
Weekly Bulletins	2	---	---	2	6
News Stand in Church Lobby	2	---	---	2	6
Announcements During Ceremonies	2	---	---	2	6
Meetings	---	7	3	10	27
Total Valid Responses	24	7	5	36	100

Finally, the gathered responses were ranked to validate the willingness of community-based organizations to participate and facilitate subsequent outreach activities to involve EJ populations in the decision-making process surrounding the proposed toll road system in Central Texas (see Table 9.8). Overall, the surveyed community-based organizations, especially the neighborhood associations and the religious groups are important "avenues" to inform and involve EJ communities potentially impacted by the toll road system in Central Texas. While eleven school officials thought the proposed toll roads would impact their constituents, only seven were willing to participate in community outreach activities.

Table 9.8 "Avenues" to Inform and Involve EJ communities in Central Texas

Criterion	Religious Groups	Schools	Neighborhood Associations	Scale and Interpretation
Most aware regarding proposed toll roads	3	1	2	3 = most 'very aware' about toll rods 2 = 'very aware' about toll roads 1 = less 'very aware' about toll roads
Thought the proposed toll road system will impact their constituents	1	2	3	3 = most concern about toll road impacts 2 = concern about toll road impacts 1 = less concern about toll road impacts
Willingness to participate in community outreach activities	2	1	3	3 = most willing to participate 2 = willing to participate 1 = less willing to participate
Identify avenues for informing communities about proposed toll road system	3	1	2	3 = more avenues for informing communities 2 = avenues for informing communities 1 = less avenues for informing communities
TOTAL =	9	5	10	

9.2.3 Conclusions and Recommendations

The insights gained from this *Telephone Survey* highlight the following:

- The importance of informing (educating) and involving the community-based organizations serving EJ populations in the decision-making process surrounding the proposed toll road system in Central Texas. Only thirty seven percent of the surveyed organizations (18) were very aware regarding the planned toll road system in Central Texas.

- The willingness of the organizations to participating in community outreach activities to help gather information about the potential positive and negative impacts that the proposed toll roads may have on their constituents. Neighborhood associations and religious groups are most willing to participate in community outreach activities compared to schools. School officials are concerned about political implications, did not have the space for meetings, were already overburdened with meetings, or were worried about the paperwork.

Finally, the salient findings from this *Telephone Survey* can be used by the Texas Department of Transportation (TxDOT) to define the goals of future EJ outreach/participation efforts in Central Texas, and aid the agency in selecting, planning, and managing EJ outreach/participation efforts that will ensure the meaningful participation of these traditionally underrepresented groups in the decision-making process surrounding the planned toll road system in Central Texas.

9.3 *DOOR-TO-DOOR SURVEY*

9.3.1 Survey Design

In March and April of 2006, in person interviews were conducted in the area potentially impacted by the proposed toll road system in Central Texas. The main objectives of the *Door-to-Door Survey* were to assess (a) how EJ communities foresee the impact toll roads will have on their travel (i.e., work trips, shopping trips, and trips to educational facilities and hospitals), (b) how EJ communities foresee the impact toll roads will have on their communities, (c) potential mitigation options preferred by the impacted community, and (d) potential “avenues” to educate the impacted EJ communities about proposed toll roads and to involve them in the decision-making process surrounding proposed toll roads.

The target population was the EJ households living in the area impacted by the proposed toll roads in Central Texas. As with the Final Environmental Impact Statement for SH 130 (U.S. Department of Transportation & Texas Department of Transportation, 2001) it was assumed that a 6-mile wide buffer along the proposed toll road alignments (see Figure 9.5) covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (the potential EJ concerns) associated with the proposed toll roads. The sampling units were the housing units in zones with high concentrations of minority and low-income populations within the impacted area (see Figure 9.5).

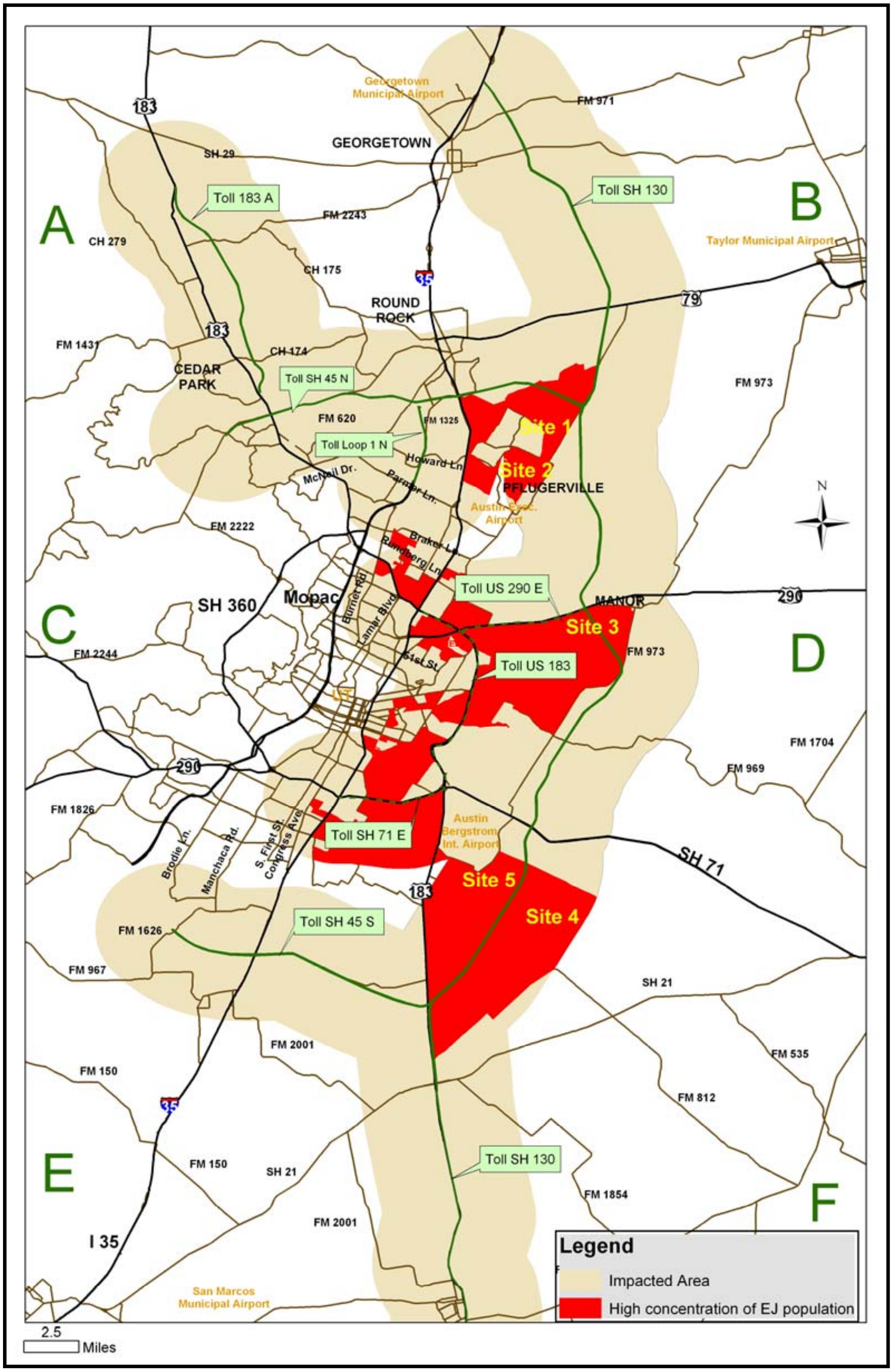

Figure 9.5 Impacted Area and Survey Sites

Based on the 2000 U.S. Census, there are 57,489 housing units within the high EJ concentration zones, which are 17% of the total housing units in the impacted area. Table 9.9 provides additional information about the minority and low-income populations in zones with high concentrations of EJ populations. Given the scope of the analysis, available budget, and time frame to conduct the analysis, the target sampling unit was established at 1% of the housing units (575 housing units) in the zones with high concentrations of minority and low-income populations.

Table 9.9 Target Population (based on the 2000 US Census)

Zones with high concentrations of minority populations		**Zones with high concentrations of low-income populations**	
Total Population =	167,137	Total Population =	166,227
Minority Population =	114,390	Low-Income Population =	32,672
% Minority Population =	68%	% Low-Income Population =	20%

Five survey sites in zones with high concentrations of minority and low-income populations were selected (see Figure 9.5). Two northern, one central, and two southern sites were identified. The housing units to be surveyed were randomly chosen from the selected survey sites.

Door-to-door surveys were conducted at the five identified survey sites. This survey method, although comparatively more costly and time consuming per respondent than other survey techniques, was chosen because it overcomes many of the barriers preventing EJ communities from participating in community outreach activities, minimizes respondent burden, and maximizes the response rate. The surveys were conducted between 10:00 a.m. and 6:00 pm on weekdays and weekend days between March 15 and April 2, 2006.

The two survey forms and accompanying maps used to conduct the door-to-door surveys are provided in Figures 9.6 and 9.7. Both survey forms were prepared in English and Spanish. Questionnaire 1 pertains only to the SH 130 toll road. Questionnaire 2 pertains to the system of toll roads planned for Central Texas, which includes new toll roads (i.e., SH 130, SH 45 North, Loop 1 North, 183A, and SH 45 Southeast) and toll lanes in the median of existing highways (i.e., US 290 East, US 183 South, and SH 71 East). The first segment of SH 130 (between IH-35 in Georgetown and US 183 near Creedmoor), SH 45 North, Loop 1 North, and 183A are currently under construction and will open to traffic at the end of this year.[18] The construction of the US 290 E is scheduled to begin in 2007. Future projects include US 183 South (Ed Bluestein Blvd), SH 71 East (Ben White Blvd.), and SH 45 Southeast.[19]

The *Door-to-Door Survey* achieved an overall response rate of 34%. From the 702 sampled housing units, 240 housing units completed the survey. In the case of remaining 462 housing units, no one opened the door or the respondent refused to participate in the survey. Approximately 57% of the housing units (136 respondents) completed Questionnaire 1 while 43% (104 respondents) completed Questionnaire 2. More details about the survey methodology, survey results and interpretation, and concluding remarks are presented in Appendix B.

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[18] Central Texas Regional Mobility Authority. Project. Available at http://www.ctrma.org/?menu_id=6. Accessed: March 3, 2006.

[19] Central Texas Regional Mobility Authority. Project. Available at http://www.ctrma.org/?menu_id=6. Accessed: March 3, 2006.

QUESTIONNAIRE 1: Toll Road SH 130 and Their Impacts

Interviewer: _________________________ Date: ________ Time: _____ Site #: ____ Map #:_____

Will Toll Road SH 130 Impact YOU?

Interviewer: Mark on the map the area where the respondent live

1. Do you **WORK**? ____ Yes ____ No
   a. If yes, Where do you **WORK**? (please mark on the map)

      ____

   a. How do you usually **GET TO WORK**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

2. Do you go to **SCHOOL**? ____ Yes ____ No
   a. If yes, Where do you go to **SCHOOL**? (please mark on the map) __________________________
   b. How do you usually **GET TO SCHOOL**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

3. Where do you usually **SHOP** FOR **GROCERIES**? (please mark on the map)

   ____

   a. How do you usually **GET TO THIS STORE**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

4. If you need to go to the **HOSPITAL**,

   Which hospital would you go? (please mark on the map)_____________________________________

   a. How would you **GET TO THIS HOSPITAL**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you would drive/take to get there?____

5. Do you think that toll road **SH 130** will **AFFECT ANY OF THE TRIPS** you listed above?

   _____Yes _____ No

   a. If yes, Which **TRIPS** will be **AFFECTED**? ___Work ___School ___Grocery shopping ___Hospital

   b. **HOW** will this toll road **AFFECT YOUR TRIPS**? ____________________________________

   ____

Figure 9.6 Questionnaire 1 and Accompanying Map

QUESTIONNAIRE 1: - Toll Road SH 130 and Their Impacts

Interviewer: ________________________ Date: ________ Time: _____ Site #: ____ Map #:____

Will Toll Road SH 130 Impact YOUR COMMUNITY?

6. Do you think that toll road **SH 130** (shown in the map) will **AFFECT YOUR COMMUNITY**?

   ___ Yes ___ No

   If yes, check all that apply

   a. Will it **BENEFIT** your community? ____ Yes ____ No

   b. Will it **BURDEN** your community? ____ Yes ____ No

   i. If the respondent said benefits, **WHAT** do you see as the **BENEFITS** of this toll road?

   ____

   ____

   ii. If the respondent said burdens, **WHAT** do you see as the **BURDENS** of this toll road?

   ____

   ____

   iii. If the respondent said burdens, **WHAT** can **TxDOT** do to **REDUCE** or **ELIMINATE** these **BURDENS**?

   ____

   ____

Do You Want to be INVOLVED?

7. Can we **CONTACT YOU IN THE FUTURE** to find out what you think about toll roads?

   ____ Yes ____ No

8. If yes, What is the **BEST WAY TO REACH YOU**? ___ Come to my home ____ Send a questionnaire

   ____ Phone me ___ Interview me at the shopping mall/grocery store ___ Come to my church

   ____ Come to one of the schools in the community

   ____ Other way. How? ____

9. Is there **ANYONE** in your community that **CAN SPEAK FOR THE COMMUNITY**?

   _____Yes _____ No

10. If yes, Could you please **SHARE HIS/HER NAME** with us? ________________________________

Personal Information (depending on answer to question 7)

Name: ____Telephone: _______________

Address: ____

ADDITIONAL COMMENTS: ____

____

Figure 9.6 Questionnaire 1 and Accompanying Map, continued

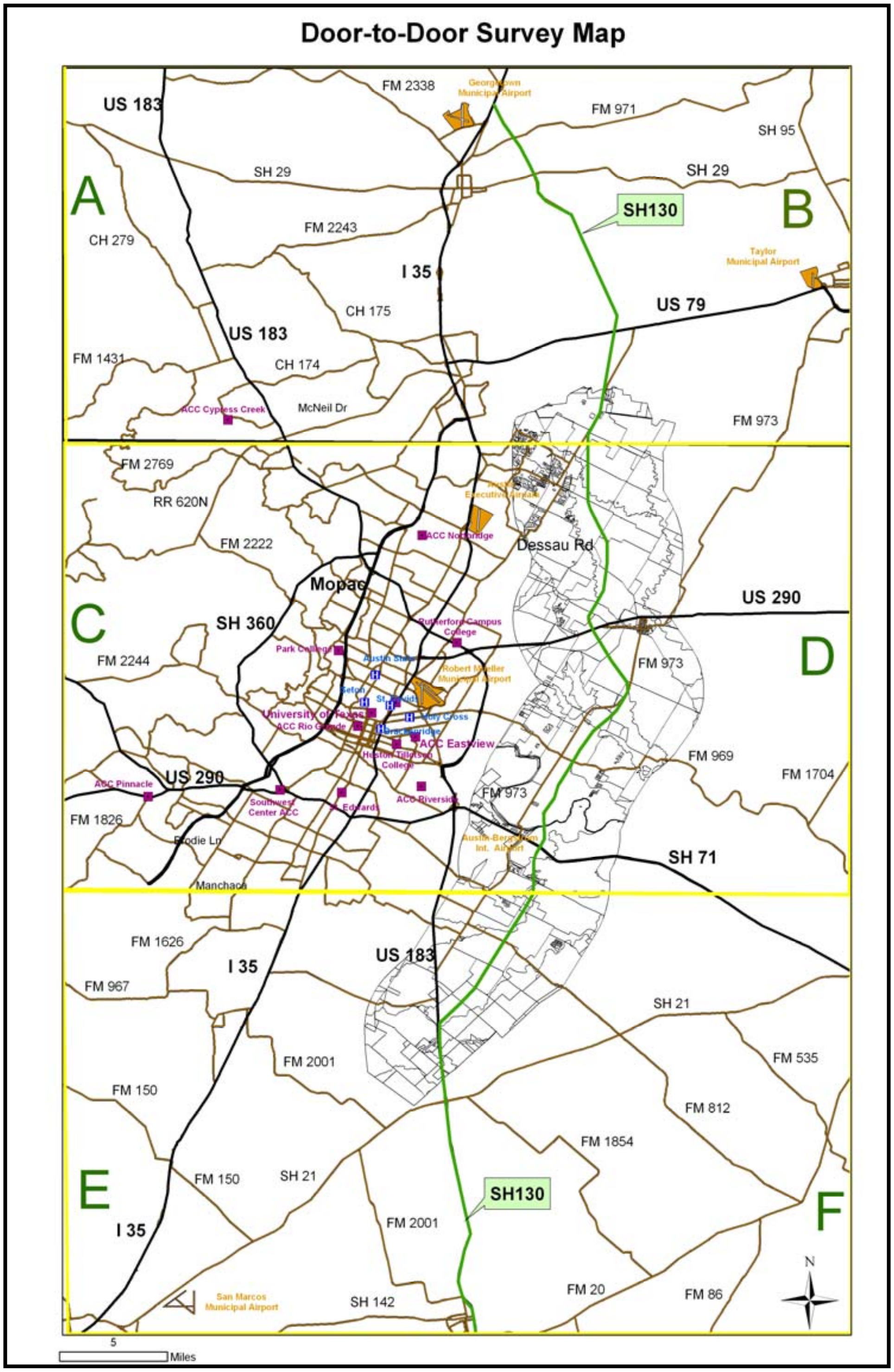


Figure 9.6 Questionnaire 1 and Accompanying Map, continued

QUESTIONNAIRE 2: Toll Roads in Central Texas and Their Impacts

Interviewer: ___________________________ Date: ________ Time: ______ Site #: ____ Map #: ____

Will TOLL ROADS in CENTRAL TEXAS Impact YOU?

Interviewer: Mark on the map the area where the respondent live

2. Do you **WORK**? ____ Yes ____ No
   a. If yes, Where do you **WORK**? (please mark on the map) ____________________________________
   b. How do you usually **GET TO WORK**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      ii. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

3. Do you go to **SCHOOL**? ____ Yes ____ No
   a. If yes, Where do you go to **SCHOOL**? (please mark on the map) ______________________________
   b. How do you usually **GET TO SCHOOL**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

4. Where do you usually **SHOP** FOR **GROCERIES**? (please mark on the map)
   ____
   a. How do you usually **GET TO THIS STORE**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

4. If you need to go to the **HOSPITAL**, Which hospital would you go? (please mark on the map) _________
   a. How would you **GET TO THIS HOSPITAL**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you would drive/take to get there? ____

5. Do you think that **TOLL ROADS** in **CENTRAL TEXAS** (shown in the map) will **AFFECT ANY OF THE TRIPS** you listed above? ___Yes __ No
   a. If yes, Which **TRIPS** will be **AFFECTED**? ___Work ___School ___Grocery shopping ___Hospital
   b. **HOW** will these toll roads **AFFECT YOUR TRIPS**? ____
   ____
   ____

Figure 9.7 Questionnaire 2 and Accompanying Map

QUESTIONNAIRE 2: Toll Roads in Central Texas and Their Impacts

Interviewer: __________________________ Date: ________ Time: ______ Site #: ____ Map #: ____

Will TOLL ROADS in CENTRAL TEXAS Impact YOUR COMMUNITY?

6. Do you think that **TOLL ROADS** in **CENTRAL TEXAS** (shown in the map) will **AFFECT YOUR COMMUNITY**?_____ Yes _____ No

   If yes, check all that apply

   a. Will it **BENEFIT** your community? _____Yes _____ No

   b. Will it **BURDEN** your community? _____Yes _____ No

   i. If the respondent said benefits, **WHAT** do you see as the **BENEFITS** of these toll roads?

   ____

   ____

   ii. If the respondent said burdens, **WHAT** do you see as the **BURDENS** of these toll roads?

   ____

   ____

   iii. If the respondent said burdens, **WHAT** can **TxDOT** do to **REDUCE** or **ELIMINATE** these **BURDENS**?

   ____

   ____

Do YOU WANT to be INVOLVED?

7. Can we **CONTACT YOU IN THE FUTURE** to find out what you think about toll roads?

   _____ Yes _____ No

8. If yes, What is the **BEST WAY TO REACH YOU**? ___ Come to my home ___ Send a questionnaire

   ____ Phone me ___ Interview me at the shopping mall/grocery store ___ Come to my church

   ____ Come to one of the schools in the community

   ____ Other way. How? ____

9. Is there **ANYONE** in your community that **CAN SPEAK FOR THE COMMUNITY**?

   _____Yes _____No

10. If yes, Could you please **SHARE HIS/HER NAME** with us? ______________________________

Personal Information (depending on answer to questions 7 and 8)

Name: ____ Telephone: _______________

Address: ____

ADDITIONAL COMMENTS: ____

____

Figure 9.7 Questionnaire 2 and Accompanying Map, continued

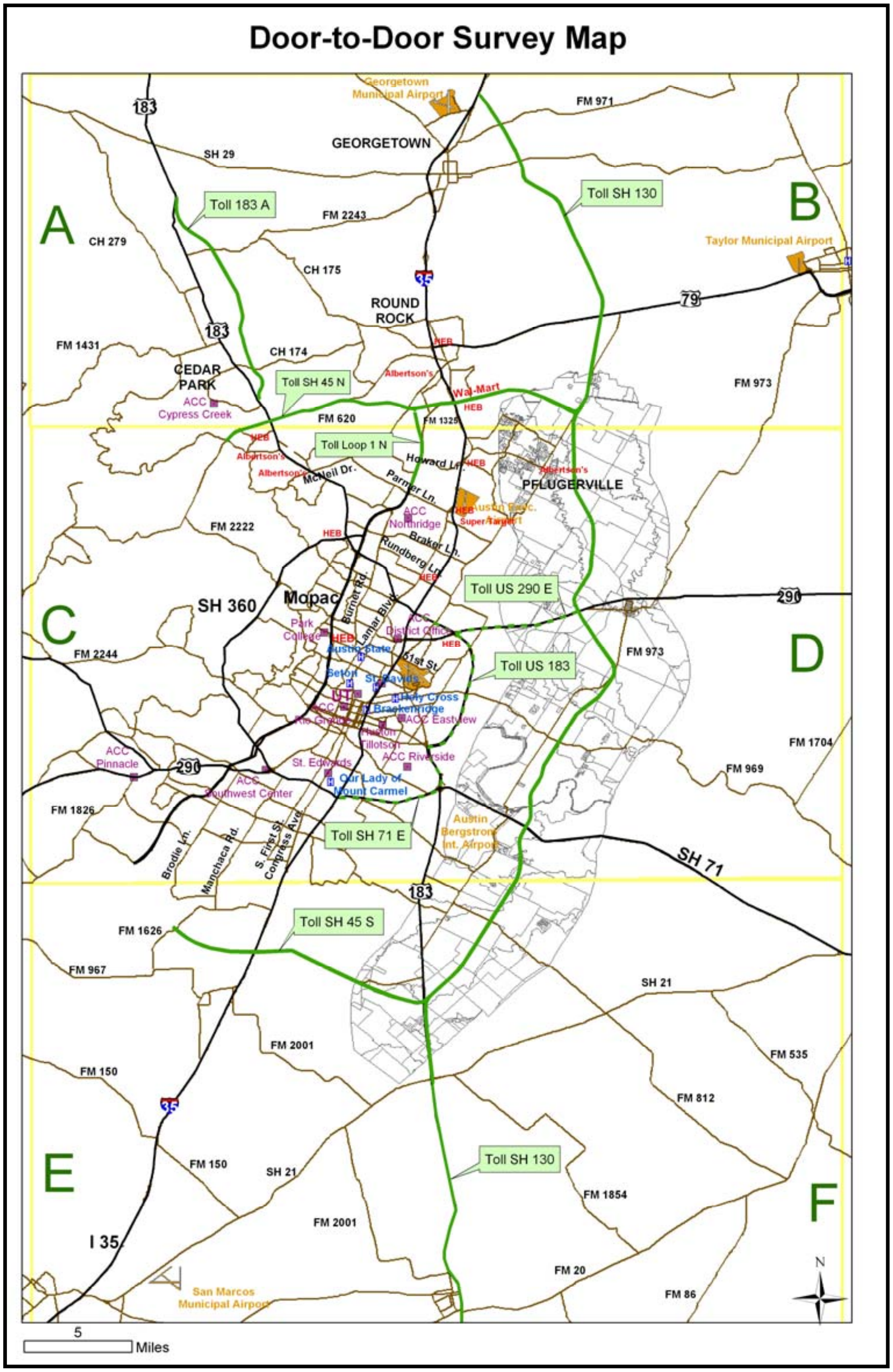


Figure 9.7 Questionnaire 2 and Accompanying Map, continued

9.3.2 Major Survey Findings

Trip Purpose by Transportation Mode

An analysis of the data revealed that the predominant transportation mode used by those surveyed to get to work, school, grocery stores, and the hospital is the car, either driving alone (87% of the respondents) or carpooling (9% of the respondents). About 2% of the respondents indicated they ride the bus and only 1% of the respondents indicated walking as their mode of transportation. In other words, minority and low-income communities in the areas potentially impacted by toll roads in Central Texas mainly rely on private cars to satisfy their transportation needs. This finding suggests that toll roads would impact the financial budges of low-income drivers if they were to use toll roads to satisfy their transportation needs.

Foreseen Impacts on Trips and Communities Imposed by Toll Roads

Table 9.10 summarizes the gathered responses regarding whether the proposed toll roads would impact the trips and communities of respondents.

Table 9.10 Results about whether Respondent's Trips and Community Will be Impacted by the Proposed Toll Roads

RESPONSE	Will toll roads affect your trips?			Will toll roads affect your community?		
	SH-130*	Toll System**	Overall***	SH-130*	Toll System**	Overall***
Yes	44 (32%)	36 (35%)	80 (33%)	96 (71%)	73 (70%)	169 (71%)
No	87 (64%)	66 (63%)	153 (64%)	30 (22%)	26 (25%)	56 (23%)
Does not know/Refuse to answer	5 (4%)	2 (2%)	7 (3%)	10 (7%)	5 (5%)	15 (6%)
TOTAL =	136 (100%)	104 (100%)	240 (100%)	136 (100%)	104 (100%)	240 (100%)

*Based on gathered responses pertained to Questionnaire 1
**Based on gathered responses pertained to Questionnaire 2
*** Based on total gathered responses

From Table 9.10, the following observations can be made:

- Overall, about one-third of the respondents (33%) indicated that the proposed toll roads would impact one or more of the type of trips listed (i.e., work, school, grocery shopping, or hospital), 64% indicated no impact on their trips, and 3% refused to answer the question or did not know if or how the toll roads would impact their trips.
- Overall, seventy-one percent of the respondents indicated that the proposed toll roads would impact their communities which is more than twice the number of respondents who indicated that the toll roads would impact their trips (33% of the respondents). Twenty-three percent indicated the toll roads would not impact their communities and six percent of the respondents refused to answer the question or did not know how the proposed toll roads would impact their communities.

Trip Purposes Potentially Impacted by the Proposed Toll Roads and Foreseen Impacts

Table 9.11 illustrates (a) the trip purposes that would be impacted by the proposed toll roads, as perceived by the 80 respondents who indicated that the toll roads would impact one or more of the types of trips listed and (b) the eight foreseen impacts (i.e., benefits and burdens) the proposed toll roads would have on the trips listed, as provided by 66 of the 80 respondents. From Table 9.11, the following observations can be made:

- The 80 respondents, who foresaw toll roads would impact their trips (see Table 2), indicated that the most impacted trip would be to work (60%), followed by trips to the hospital (50%), and to grocery stores (49%). Trips to school were foreseen to be less impacted by the toll roads (11%). This is can be explained by the fact that most school trips are local trips.

Table 9.11 Respondents' Trips Affected by the Proposed Toll Roads and Foreseen Impacts

TRIP PURPOSE			Respondents	Percent*
Work			48	60%
School			9	11%
Shop Groceries			39	49%
Hospital			40	50%
FORESEEN BENEFITS			Frequency	Percent**
1. Decrease travel time/distance			11	16%
2. Alleviate congestion on existing roads			6	9%
3. Provide drivers with more roads to satisfy their transportation needs			1	1%
		SUB-TOTAL=	18	27%
FORESEEN BURDENS			Frequency	Percent**
4. Increase travel cost			26	39%
5. Increase travel time			12	18%
6. Reduce number of discretionary trips			5	7%
7. Force drivers to find alternative roads to avoid the toll			5	7%
8. Decrease travel safety			1	1%
		SUB-TOTAL =	49	73%
		TOTAL =	67	100%
TYPE OF QUESTIONNAIRE	**BENEFITS**		**BURDENS**	
	Frequency	Percent	Frequency	Percent
SH-130	10	29%	24	71%
Toll System	8	24%	25	76%

*Based on 80 respondents who indicated that the toll roads will impact the types of trips listed
**Based on 67 responses provided by 66 respondents

- Sixty-six of the 80 respondents (82%) who indicated that the toll roads would impact one or more of their trips listed an impact. Sixty-five respondents listed one benefit or burden, and only one respondent listed one benefit and one burden. The remaining 14 respondents (18%) were unable to list an impact. The results point to a lack of understanding of how the proposed toll road system in Central Texas may affect the trips of the respondents.

- Of the 67 impacts listed, it was found that 27% were foreseen benefits while the remaining 73% were foreseen burdens.
- The respondents foresaw that the added capacity provided by the toll roads would help to reduce travel time and distance (representing 16% of the impacts) and alleviate congestion on existing roads (9% of the impacts). A few of the respondents mentioned that the toll roads would reduce traffic on I-35 and FM 973.
- Most of the respondents, however, foresaw that the toll roads would increase their travel cost (39% of the impacts) and travel time (18% of the impacts). In terms of travel cost, the respondents anticipate the following burdens: (a) drivers will have to pay for using SH 290 in the future that at present is "free", (b) on Sundays, the cost of trips to church will increase if the toll roads is used, and (c) the toll roads will increase the travel cost of local business customers. In terms of travel times, the respondents mentioned the following burdens: (a) the toll roads will attract more vehicles to the area, (b) drivers will have to stop to pay for the toll, and (c) drivers avoiding the toll roads will increase traffic on local streets.
- Fourteen percent of the impacts concerned the fact that toll roads would force the respondents to limit their discretionary trips and seek alternative roads to avoid the tolls. Some respondents felt that they may have to change the places they shop.
- The respondents associated fewer benefits with the toll road system as compared to the SH 130 toll road (24% of the impacts compared to 29% of the impacts). Consequently, the respondents foresaw more burdens being imposed on their travel trips with the toll road system in Central Texas as

compared to the SH 130 toll road (76% of the impacts compared to 71% of the impacts).

Will Proposed Toll Roads Benefit/Burden Respondents' Community?

Table 9.12 summarizes the gathered responses regarding whether the community of the respondents would benefit/burden from/by the proposed toll roads and the eight foreseen impacts (i.e., benefits and burdens) the proposed toll roads would have on the community of respondents, as provided by 105 respondents who listed 106 benefits and 107 respondents who listed 109 burdens. From Table 9.12, the following observations can be made:

- Overall, 48% of the respondents indicated that the toll roads would benefit their communities while 24% did not foresee any benefits from the toll roads. About 28% of the respondents refused to answer or did not know. Of those surveyed about the toll road system in Central Texas, 34% of the respondents did not know whether the proposed toll roads would benefit their communities or refused to answer this question. This could point to a lack of understanding of how toll roads could impact the communities and thereby necessitating additional public participation efforts to inform and educate these communities about the proposed toll road system in Central Texas.
- Overall, 47% of the respondents indicated that the toll roads would burden their communities while 24% did not foresee any burdens imposed by the toll roads. About 29% of respondents did not know whether the proposed toll roads would burden their communities or refused to answer this question.

Table 9.12 Foreseen Community Benefits and Burdens from Proposed Toll Roads

RESPONSE	Will toll roads benefit your community?		Will toll roads burden your community?	
	Respondents*	Percent	Respondents*	Percent
Yes	114	48%	112	47%
No	58	24%	58	24%
Does not know/Refuse to answer	68	28%	70	29%
TOTAL =	240	100%	240	100%
RESPONSE	**BENEFITS**		**BURDENS**	
Respondents who listed impacts	105	92%	107	96%
Respondents who refused to list an impact	9	8%	5	4%
TOTAL =	114	100%	112	100%

FORESEEN BENEFITS	Frequency	Percent*
1. Environmental benefits	1	1%
2. Mobility benefits	77	73%
3. Safety benefits	1	1%
4. Social and economic benefits	27	25%
TOTAL =	106	100%

Note: Environmental benefits relate to less pollution. Mobility benefits comprise reduced traffic on congested roads, faster routes, and more options for drivers. Safety benefits include fewer traffic accidents. Finally, social and economic benefits include attracting new businesses and increasing property values.

FORESEEN BURDENS	Frequency	Percent**
5. Environmental burdens	6	6%
6. Mobility burdens	16	15%
7. Safety burdens	2	2%
8. Social and economic burdens	85	78%
TOTAL =	109	100%

Note: The environmental burdens listed relate to increased air pollution/traffic noise, and increase of flooding areas. Mobility burdens mentioned by respondents include increased traffic jams in areas close to construction zones, worsened traffic conditions on entry/exit ramps, increased trip length, slower traffic due to toll booths, and increased traffic ticketing. The safety burdens listed relate to an increase in traffic accidents. Finally, the social and economic burdens listed include the following: affect driver's transportation budget, increase traffic through neighborhoods, affect quality of life in the community, increase driver's stress, hamper community cohesion, encourage community segregation by income level, decrease property values of homes near toll roads, necessitate relocation of homes and businesses, and increase property taxes.

* Based on 106 responses provided by 105 respondents
** Based on 109 responses provided by 107 respondents

- Nine of the respondents who indicated that the toll roads would have a positive impact on their communities (8% of the 114 respondents) were not able to list a benefit while five of the respondents (4% of the 112 respondents) who indicated that the toll roads would have a negative impact on their communities were not able to list a burden. This is significantly fewer than the respondents who could not indicate how the proposed toll roads would impact their trips.

- Of the 114 respondents who indicated that toll roads would have a positive impact on their communities, 105 (92%) listed 106 benefits, while 107 of the 112 respondents (96%) who indicated that the toll roads would have a negative impact on their communities listed 109 burdens.
- The respondents who foresaw benefits indicated that the toll roads would provide improved surface mobility (73% of the responses), an increase in social and economic benefits (25% of the responses), an improved environment (1% of the responses), and enhanced highway safety (1% of the responses).
- Forty-three percent of the responses, categorized as "mobility benefits", referred to a reduction in traffic on congested roads such as I-35, SH 290, and Loop 1 (Mopac). Some respondents mentioned that the SH 130 toll road will reduce truck traffic on I-35. In addition, 21% of the responses indicated that the toll roads will provide faster routes compared with the existing roads.
- The respondents who foresaw burdens indicated that the toll roads would impose social and economic burdens on their communities (78% of the responses), and a negative impact on mobility (15% of the responses), the physical environment (6% of the responses), and highway safety (2% of the responses).

- The most often cited "social and economic burden" was the negative impact that the toll roads would have on the financial budget of the driver (43% of the responses) because drivers would have to pay for using the toll roads. Also a number of respondents felt that the toll roads would negatively impact the quality of life in their communities by attracting more people to the area (18% of the responses).

Mitigation Options Preferred by the Impacted EJ communities

Of the112 respondents who indicated that toll roads would burden their community, only 57 (51%) could list a mitigation option to lessen or avoid the negative impacts. Table 9.13 summarizes the thirteen (13) mitigation options listed by the 57 respondents to minimize or eliminate the burdens imposed by the proposed toll roads on the EJ communities.

Table 9.13 Proposed Mitigation Options

MITIGATION OPTIONS	Frequency	Percent*
1. Do not build toll roads/Continue to pay for roads with tax dollars	25	43%
2. Put the toll road decision up to a vote	6	11%
3. Upgrade and improve existing non-toll roads for those who cannot afford the tolls (e.g., improve connectivity and safety of existing roads, improve traffic light management)	6	11%
4. Improve community outreach to inform and involve the community in the planning, design, and construction of toll roads	5	9%
5. Provide better public transportation for those who cannot afford the toll	3	5%
6. Provide "free passes" to those living near toll roads and low-income people who cannot afford the toll	3	5%
7. Only build toll road through commercial areas	2	3%
8. Do not allow truck traffic on toll roads	2	3%
9. Charge reasonable toll fees	1	2%
10. Build noise walls	1	2%
11. Provide tags so drivers do not have to stop to pay the toll	1	2%
12. Limit toll road construction to off-peak travel hours	1	2%
13. Relocate affected properties	1	2%
TOTAL =	57	100%

* Based on 57 responses provided by 57 respondents

From Table 9.13, the following observations can be made:

- The relative low response rate for this question might confirm one of the typical barriers to EJ community participation in decisions surrounding toll road projects: limited understanding of how a project will affect their lives and how participation in the process would benefit them. It also points to a need for additional outreach activities to inform and involve the EJ communities in the decision-making process surrounding toll roads in Central Texas.
- The most frequently proposed mitigation option was to not build toll roads and/or continue to pay for roads with tax dollars (43% of the responses). Also, a number of respondents said that the toll road decision should be put up to a vote (11% of the responses). These findings indicate a relatively strong opposition against toll roads.
- Third, the respondents proposed improvements to the connectivity and safety of the existing non-toll roads so those who could not afford the toll would have a comparable alternative to satisfy their transportation needs (11% of the responses).
- Fourth, the respondents listed better community outreach to inform and involve the community in the planning, design, and construction of toll roads (9% of the responses). This points to the need for increased involvement of the traditionally underrepresented groups in the decision-making process surrounding toll road projects in Central Texas.
- Finally, a number of respondents listed the provision of better public transportation in low-income areas so drivers who could not afford the toll would have an alternative transportation mode (5%) and the provision of "free

passes" to those living near toll roads and low-income drivers who could not afford the toll (5%).

Willingness to Be Involved and Preferred Participation Techniques

Table 9.14 summarizes the gathered responses regarding the willingness of respondents to be contacted in the future to provide input in the decision-making process surrounding toll roads and the preferred community participation techniques listed by respondents. From Table 9.14, the following observations can be made:

- Seventy-seven percent of the respondents indicated that they were amenable to being contacted in the future to provide input in the decision-making process surrounding toll roads. The remaining 23% did not want to be contacted in the future.

Table 9.14 Respondents' Willingness to Be Contacted in the Future and Preferred Community Outreach Efforts

Respondents' Willingness to Be Contacted in the Future	Respondents	Percent
Yes	184	77%
No	56	23%
TOTAL =	240	100%
Respondents' Willingness to Be Contacted in the Future	Respondents	Percent
Given that toll roads would affect any of the respondents' trips	66	83%*
Given that toll roads would affect respondents' community	130	77%**
Preferred Community Outreach Efforts	Responses	Percent
Phone me	86	43%
Send a questionnaire	56	28%
Come to my home	39	20%
Interview me at the shopping mall/grocery store	1	1%
Come to my church	1	1%
Come to one of the schools in the community	2	1%
Internet (e-mail)	14	7%
TOTAL =	199	100%

*Based on 80 respondents who indicated that the toll roads will impact the types of trips listed
**Based on 169 respondents who indicated that the toll roads will impact their communities

- More than 80% of the respondents who indicated that the proposed toll roads would impact their trips and 77% of the respondents who indicated that the proposed toll roads would impact their communities were willing to provide input in the decision-making process surrounding toll roads in Central Texas.
- The 184 respondents who were amenable to being contacted in the future provided 199 responses pertaining to the "avenues" (i.e., community participation techniques) which they preferred contact. These were 'phone me' (43% of the responses), 'send a questionnaire' (28% of the responses), and 'come to my home' (20% of the responses). On the other hand, the less preferred participation techniques were 'interview me at the shopping mall/grocery store' (1% of the responses), 'come to my church' (1% of the responses), and 'come to one of the schools in the community' (1% of the responses). Also, 7% of the respondents indicated that the best way to contact them was through electronic mail (i.e., internet).

Leaders in the Community

Table 9.15 summarizes the gathered responses regarding whether the respondents could identify a community leader that could speak on behalf of the impacted community and the community leaders identified by 59 respondents. From Table 9.15, the following observations can be made:

- Only 25% of the respondents indicated that someone in the community could speak for the community, while 75% said that there was no one that could speak for the community. This may suggest that there are no community leaders who could represent the majority view. Also, community cohesion may be weak to moderate in these communities.

Table 9.15 Leaders in the Community

Anyone can speak for the community	Respondents	Percent
Yes	59	25%
No	181	75%
TOTAL =	240	100%
Community leaders identified by respondents	Respondents	Percent
Individual (e.g., neighbor)	20	35%
City mayor	16	27%
Homeowners association/Community center	9	15%
City council member/Local representative	5	8%
Church pastor	2	3%
Did not provide name	7	12%
TOTAL =	59	100%

- Thirty-five percent of the respondents identified an individual (e.g., a neighbor) as the person who could speak for the community, followed by 27% of the respondents who identified the city mayor, or a representative from the homeowner association/community center (15% of the respondents), a city council member/local representative (8% of the respondents), and a church pastor (3% of the respondents).

9.3.3 Conclusions and Recommendations

In general, transportation agencies recognize the need for and the clear benefits of Environmental Justice (EJ) community participation, but the tasks are often more challenging than first anticipated. This in part because conditions need to be created to encourage the participation of people who do not have technical backgrounds, do not speak English, or do not have previous knowledge of toll road issues. A distinct approach is thus needed to ensure the meaningful participation of minority and low-income communities in the decision-making process regarding toll road projects. This often times requires (a) *Understanding the impacted EJ communities* and (b) *Educating the impacted EJ communities*. *Understanding the impacted EJ communities* is imperative to reach out to these communities effectively and to distinguish the effort from public participation efforts in general. Without a true understanding of the impacted EJ communities, the transportation agency risks selecting a participation technique that is inappropriate or a mitigation option that does not address the concerns of the EJ communities. *Educating the impacted EJ communities* will help to build the community's capacity to participate in the decision-making process surrounding toll road projects because an educated EJ community is better prepared to understand the technical issues and argue their concerns. In this regard, the results of the *Door-to-Door Survey* described in this paper point to the following:

- The need for increased public understanding of how the proposed toll road system in Central Texas may affect the trips of minority and low-income populations to get to work, school, grocery stores, and the hospital. Fourteen of the 80 respondents (18%) who indicated that the toll roads would impact one or more of their trips were unable to indicate how the toll road(s) would impact their trips.
- The need for increased public understanding of how the proposed toll road system in Central Texas may affect the EJ communities and how to mitigate any burdens imposed. Nine of the respondents who indicated that the toll roads would have a positive impact on their communities (8% of the 114 respondents) were unable to list a benefit. Five of the respondents (4% of the 112 respondents) who indicated that the toll roads would have a negative impact on their communities were unable to list a burden. Of concern though

is that about half of the 112 respondents (55), who indicated that toll roads would burden their community, were unable to list a mitigation option to lessen or avoid the negative impacts

- The need for increased understanding of the reasons for the proposed toll roads in Central Texas. While the mobility needs of Texas are significant (i.e., only $102 billion of the $188 billion will be available to achieve an acceptable level of mobility by 2030) and the Texas funding sources are stretched (i.e., the state gas tax only pays for 32% of the current state transportation budget) (Texas Department of Transportation. 2006c), the most frequently proposed mitigation option by respondents was not to build toll roads and/or continue to pay for roads with tax dollars (43% of the responses). Also, a number of respondents said that the toll road decision should be put up to a vote (11% of the responses).
- Minority and low-income people in Central Texas preferred to contribute to the decision-making process surrounding toll road projects through the following "avenues": 'phone me', 'send a questionnaire', and 'come to my home'. Also, while the internet (i.e., e-mail) is an option to involve and inform EJ communities in Central Texas, meetings or interviews at local schools/churches/shopping malls/grocery stores were the least preferred participation techniques by respondents.

Finally, the insights gained from this *Door-to-Door Survey* can be used by the Texas Department of Transportation (TxDOT) to define the goals of future EJ outreach/participation efforts in Central Texas, and to aid the agency in selecting, planning, and managing EJ outreach/participation efforts that will ensure the meaningful participation of these traditionally underrepresented groups in the decision-making process surrounding the planned toll road system in Central Texas..

9.4 STRATEGIC LOCATIONS FOR LIAISING WITH EJ COMMUNITIES

This research presents an approach to identify strategic points for liaising with EJ communities. The recommended approach is tested using data from the area potentially impacted by the system of new toll roads planned for Central Texas.

9.4.1 Methodology

The approach consists of three steps. First, the EJ concentration zones within the impacted area are compiled based on the spatial concentration of EJ populations (see Chapter 5). Second, regions, which represent the area of influence of the community outreach efforts, are identified based on the average non-work trip length travel by the low-income population in the study area. Third, for each region a spatial mean center weighted by the concentration level of EJ populations within the region is estimated as follows:

$$\boxed{\left(\bar{x}_{\text{wmc}}, \bar{y}_{\text{wmc}}\right) = \left(\frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}, \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \right)}$$

where $\bar{x}_{wmc}, \bar{y}_{wmc}$ defines the coordinates of the weighted mean center; x_i, y_i are the coordinates of the centroid of the EJ concentration zone i, and w_i is the weight at centroid i (i.e., the concentration level of zone i). By doing so the mean center is pulled closer to the EJ concentration zones with the highest concentration levels of EJ populations. Finally, strategic points for liaising with the community are identified by overlapping the weighted spatial mean centers with layers that contain community facilities (e.g., churches and schools) and the transportation systems (e.g., roads and public transit). By scheduling community outreach activities at places within the community, holding meetings at locations accessible by public transit, and providing transportation for those who do not have means to get to these places, the transportation agency might overcome some of the barriers faced by EJ communities that prevent meaningful public participation.

9.4.2. Empirical Results

The approach presented in this research is tested using information from the area potentially impacted by the system of new toll roads planned for Central Texas (i.e., SH 130, SH 45 North, Loop 1 North, 183A, and SH 45 Southeast) (see Figure 9.8). The first segment of SH 130 (between IH-35 in Georgetown and US 183 near Creedmoor), SH 45 North, Loop 1 North, and 183A are currently under construction and will open to traffic at the end of this year.

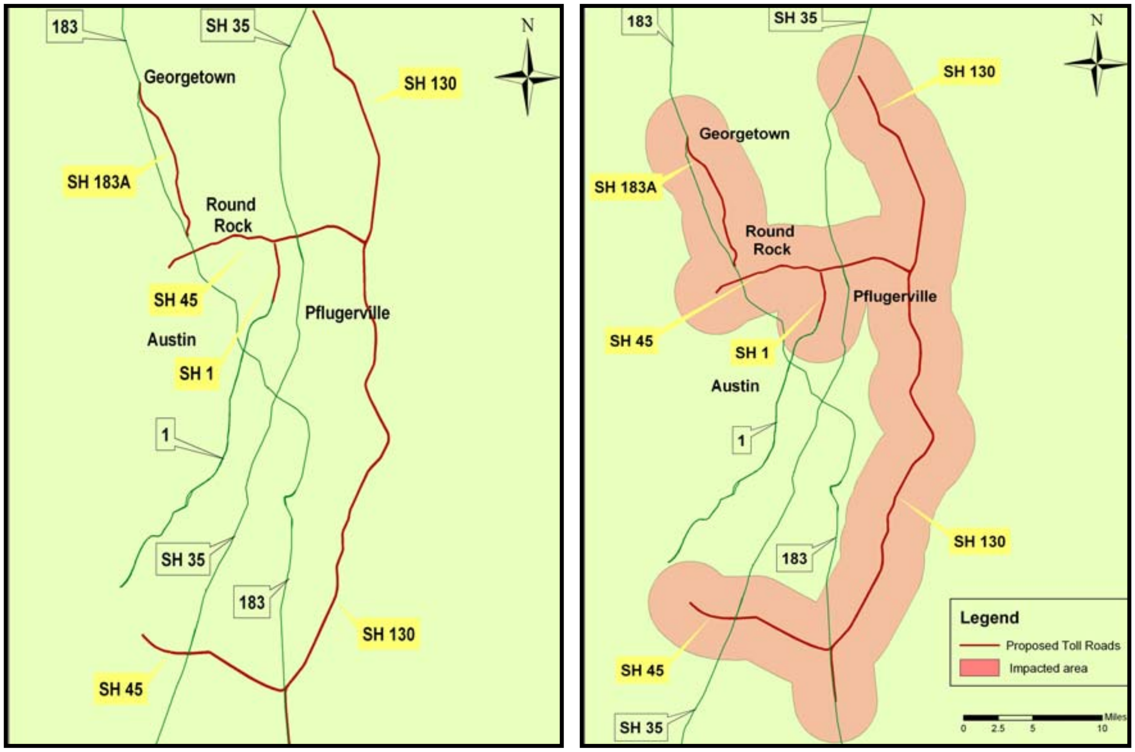


Figure 9.8 New Toll Roads Planned for Central Texas and their Impacted Area

The local Moran statistic (a local measure of spatial autocorrelation) for each census block group within the affected area was estimated. Based on the spatial patterns displayed by the Moran scatter plot (see Figure 9.9), the EJ populations were categorized by concentration levels (see Table 9.16 and Figure 9.10).

Minority population	Low-income population

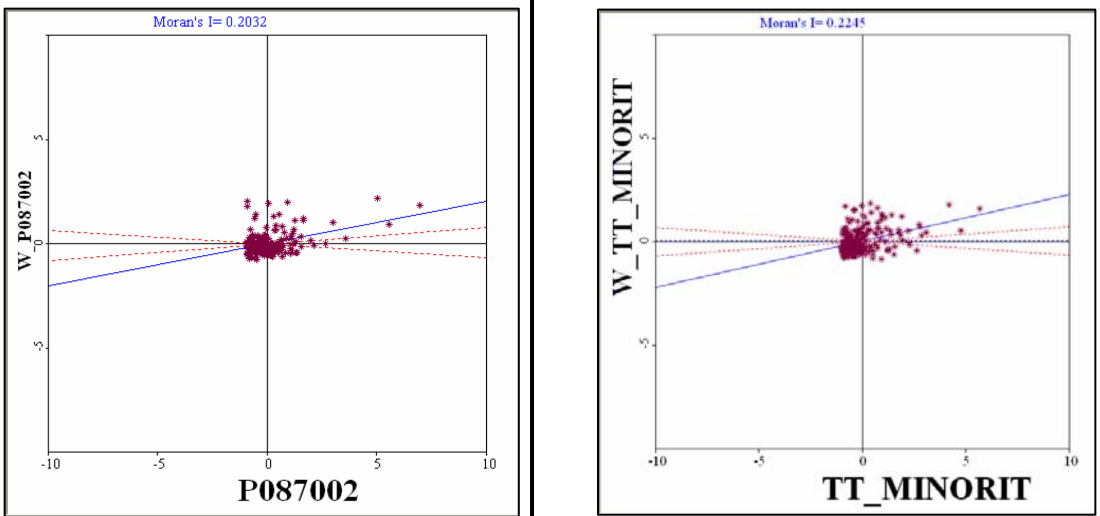


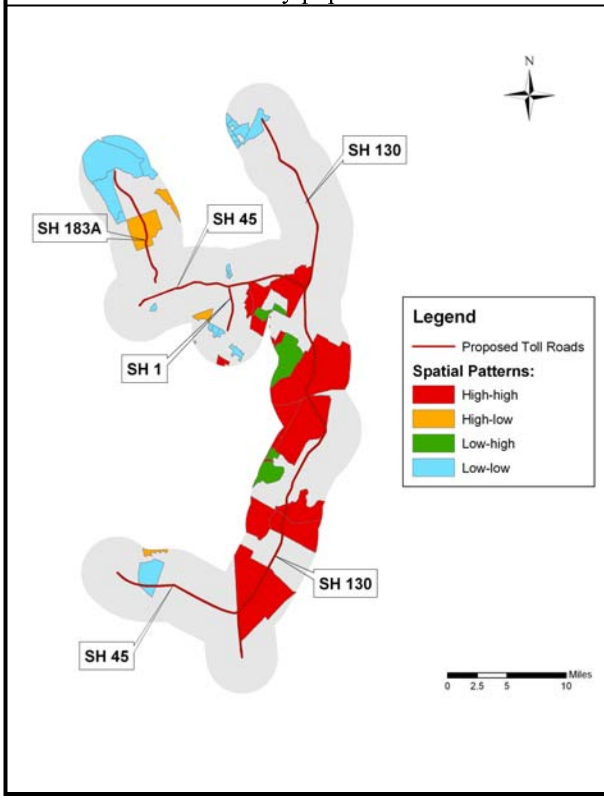
Figure 9.9 Clustering Spatial Patterns for EJ Populations within the Area Impacted by the System of New Toll Roads Planned for Central Texas

Table 9.16 Cell Values for the Raster Maps Displaying the Spatial Patterns of EJ Populations in the Area Impacted by the System of New Toll Roads Planned for Central Texas

Spatial patterns	Cell values	
	Minority Population	Low-Income Population
No pattern*	0	0
Low-low	1	10
Low-high	2	20
High-low	3	30
High-high	4	40

*No statistical significant pattern at α = 0.05

Minority population



Low-income population

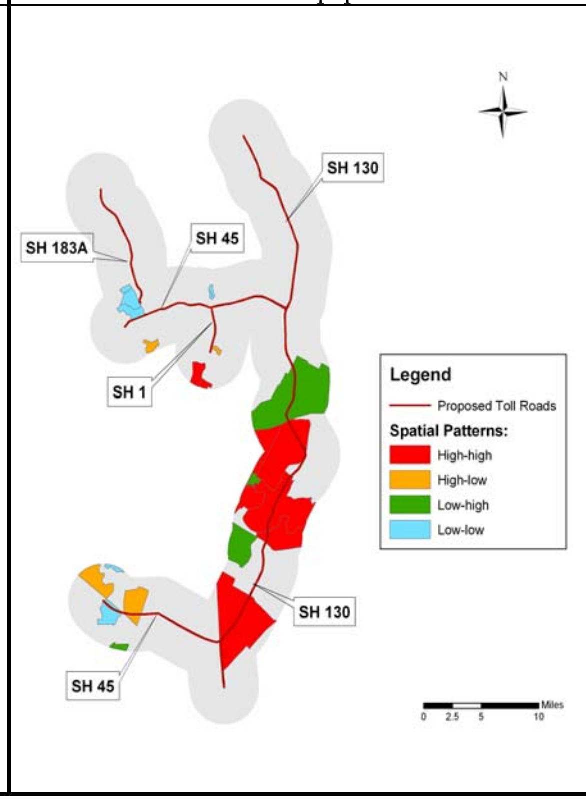


Figure 9.10 Statistically Significant Spatial Patterns of EJ Populations in the Area Impacted by the System of New Toll Roads Planned for Central Texas ($\alpha = 0.05$)

The EJ concentration zones within the impacted area are shown in Table 9.17 and Figure 9.11. The final outcome map contains 39 zones. Fourteen concentration levels of EJ population are present within the impacted area. In addition, the presence of “hot spots” of both minority and low-income populations are particularly noticeable in the south and central portions of the affected area. To validate the results from the spatial analysis, windshield surveys were conducted in the months of October and November, 2005. These surveys focused on the largest concentration zones. The observed and mapped concentration patterns were consistent.

Table 9.17 Cell Values for the Raster Maps Displaying the Concentration Levels of EJ Populations in the Area Impacted by the System of New Toll Roads Planned for Central Texas

Spatial patterns for minority population	Spatial patterns for low-income population				
	No pattern*	Low-low	Low-high	High-low	High-high
No pattern*	0	10	20	30	40
Low-low	1	11	21	31	41
Low-high	2	12	22	32	42
High-low	3	13	23	33	43
High -high	4	14	24	34	44

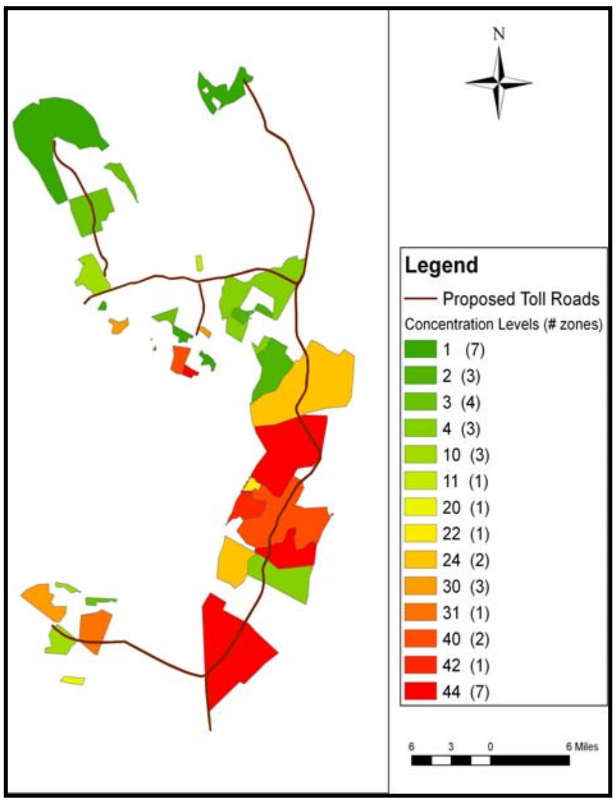


Figure 9.11 EJ Concentration Zones within the Area Impacted by the System of New Toll Roads Planned for Central Texas

The EJ concentration zones in the area potentially impacted by the system of new toll roads planned for Central Texas is split into regions. Each region has a radius of 6 miles. This radius represents the average non-work trip length traveled by low-income households in Austin, Texas (Clifton and Handy, 2001). A spatial mean center weighted by the concentration level of the EJ zones within the region is estimated for each region (see Figure 9.12). By overlaying these mean centers with schools, churches, roads, and public transportation routes within the affected area, strategic places to reach out to the EJ communities at locations convenient to them have been identified (see Figure 9.13).

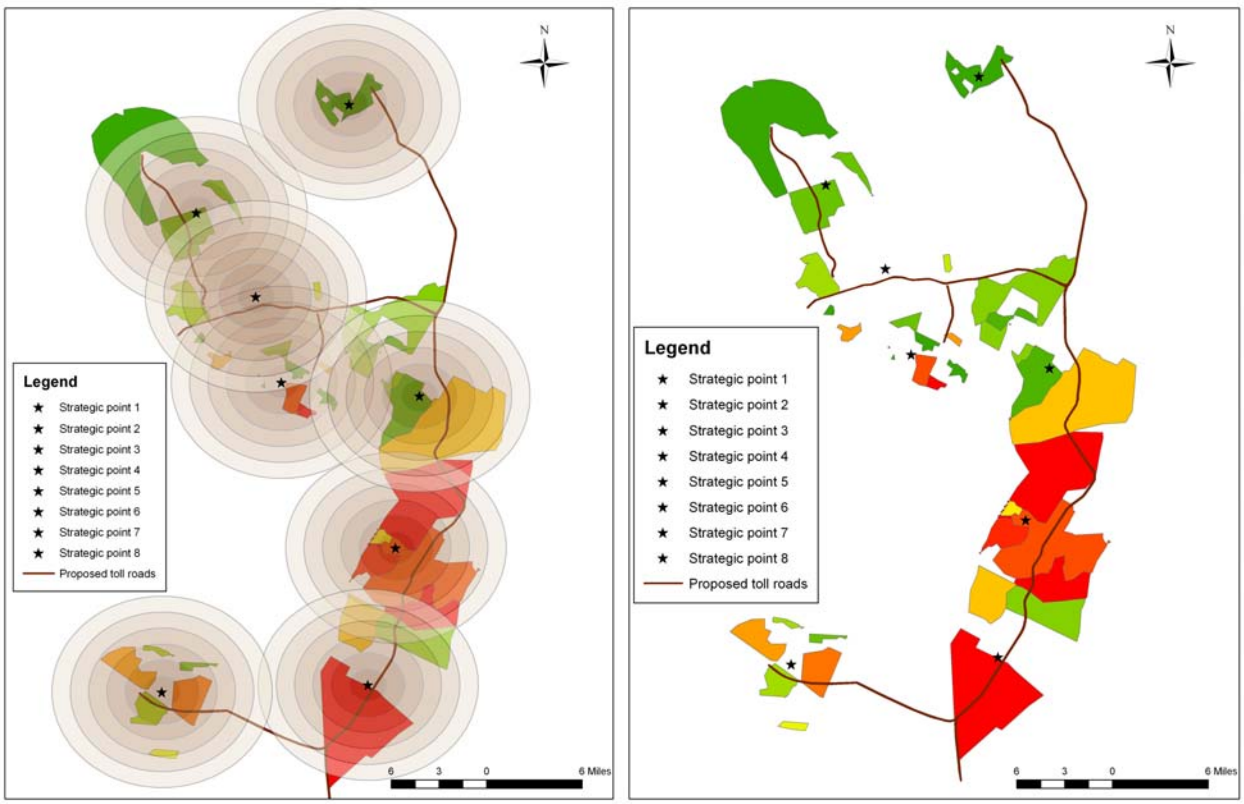
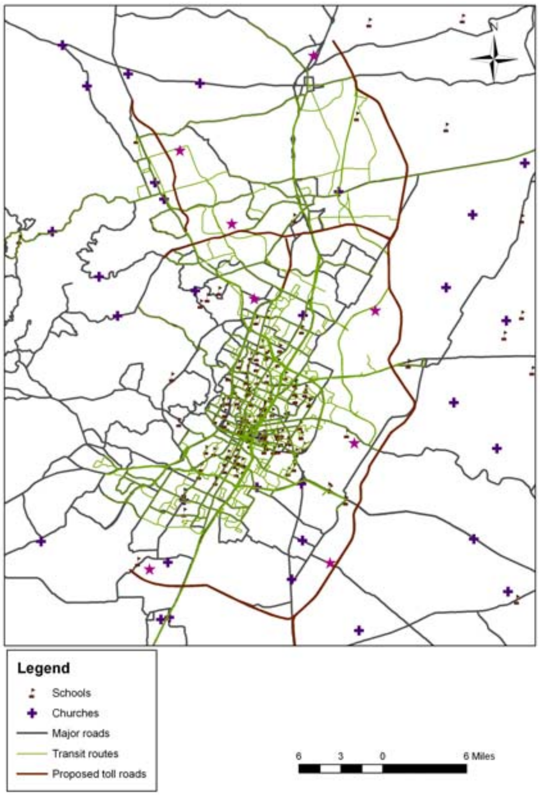


Figure 9.12 Weighted Spatial Means within the Area Impacted by the System of New Toll Roads Planned for Central Texas



Strategic Point Number	Potential Places for Community Outreach
1	Independent schools New Hope Church
2	Summit School
3	Saint Williams School
4	Manor High School
5	Travis State School
6	Salem Church
7	The Marbridge School Bethel Church
8	Ranger School Bell School

Figure 9.13 Strategic Points to Meet the EJ Communities

9.4.3 Conclusions and Recommendations

This research shows the role of Geographic Information Systems (GIS) and spatial analysis for identifying strategic locations to reach out to the EJ communities potentially impacted by a system of toll roads. Strategic points are identified as a function of (a) the average non-work trip length traveled by low-income households in the study area, (b) the concentration levels of the EJ populations (EJ concentration zones) within the area of influence of the community outreach efforts (region), and (c) the community and transportation facilities in the region. By doing so, the proposed approach aims to overcome some of the common barriers that may prevent meaningful EJ public participation in the decision-making process surrounding toll road projects (e.g., to schedule formal/informal meetings at places within the community that are located within the average non-work trip length traveled by low-income households, that may be accessible by public transit or may require transportation arrangements for those who have no modes of personal transportation).

9.5 CONCLUDING REMARKS

The insights gained from the two cases identified by the FHWA to exemplify effective practices in promoting Environmental Justice (EJ) principles, the major findings from the *Telephone* and *Door-to-Door Survey*s, and the role of Geographic Information Systems (GIS) and spatial analysis in strengthening EJ public participation by helping to identify community-based organization within the impacted area and strategic location for liaising with the EJ communities provides the basis to define (a) the general approach to ensure meaningful participation in each step of the EJEM (Chapter 10) and (b) the specific goals of the EJ outreach effort during each stage of the EJEM (Chapter 11).

Chapter 10 EJ Participation: General Approach

Effective public participation techniques have been well researched, but the "meaningful" involvement of Environmental Justice (EJ) communities requires a new perspective and emphasis, partly because conditions needs to be created that encourage the participation of people who may not have technical backgrounds, do not speak English, do not have previous knowledge of toll road issues, or distrust of government agencies. A distinct approach is thus needed to ensure the meaningful participation of minority and low-income communities in the decision-making process surrounding proposed toll road projects. The general approach to ensure meaningful participation at each step of the EJ Evaluation Methodology (EJEM) can be outlined as follows:

- Understanding the EJ community.
- Involving the EJ community in designing the public participation effort.
- Defining the goals of the EJ outreach/participation effort.
- Identifying and selecting the most appropriate participation technique(s).
- Planning, implementing, and evaluating the selected participation technique(s).

Effective and meaningful EJ participation should, in principle, result in a win-win situation for both the impacted EJ communities and the transportation agency. For example, the transportation agency will face less controversy during the planning, design, and construction of toll projects and the EJ communities will ensure projects that consider their wants and needs. In general, transportation agencies recognize the need for and the clear benefits of EJ community participation, but the tasks are often times more challenging than first anticipated.

10.1 UNDERSTANDING THE EJ COMMUNITY

The transportation agency should first and foremost gain a true understanding of the impacted EJ communities. In addition to gathering basic demographic information describing the population, the transportation agency should advance its knowledge regarding the barriers that prevent meaningful EJ public participation. Although each community impacted by a toll road project exhibits unique barriers to participation, there are some common barriers that may be expected. This research has compiled a number of typical barriers faced by EJ communities and measures that may be implemented to overcome the barriers listed (see Table 10.1).

Understanding the impacted EJ communities is essential to ensure that the selected public participation techniques fit into its lives and, with proper management, get the most useful results. Without a true understanding of the barriers preventing meaningful participation by the EJ community, the transportation agency risks selecting inappropriate participation techniques or locations to hold events.

The U.S. Census captures information based on socio-demographic characteristics that can help the transportation agency understand the lifestyles of the minority and low-income populations of the impacted community (see Table 10.2). This information can also help to identify potential barriers that may prevent participation in the outreach activities.

Table 10.1 Typical Barriers Faced by EJ Communities

Barrier	Resulting Challenges	Example of Overcoming the Barrier
Individuals holding multiple jobs/unusual job hours	• Time constraints prevent participation in community outreach activities	• Take outreach activities to them (e.g., schedule community outreach activities at days and times convenient to EJ people or at an already scheduled community event)
Low levels of education/ literacy issues	• Less understanding of potential impacts of toll roads • Less understanding of rights • Unable to provide written responses/comments	• Hire consultants with special expertise in communicating with people who have low or no education
Unique family structures (e.g., single parents, multi-generational families)	• Time constraints prevent participation due to family obligations, such as caring for children and elderly	• Provide care for children and the elderly during community outreach activities
Less likely to have modes of personal transportation (i.e., private car)	• Greater difficulty getting to community outreach activities • Less concerned about toll road projects if they do not intend to use it	• Hold meetings at locations accessible by public transit • Schedule community outreach activities at places within the community, such as schools, parks, and community centers • Provide transportation to community outreach activities • Ensure access for the elderly and people with disabilities
Less access to internet/technology/computer literacy issues	• Use of Web sites and e-mails to inform and involve EJ communities would be ineffective	• Distribute printed materials at laundry facilities, homeless shelters, employment offices, food banks, post offices, bus stops/transit stations, churches, parks, health clinics, grocery stores, and community centers. • Distribute information via local radio stations (National Academy of Public Administration, 2001) • Use flyer inserts in newspapers (e.g., Latino papers) or distribute information via school district newsletters/cultural programs
Language barriers	• Less ability to participate in public involvement efforts • Less aware of opportunities to influence toll road project outcomes	• Translate public documents, notices, and hearings for limited English speaking populations • Provide translations and use bilingual speakers during community outreach activities • Prepare communication materials for limited English speaking populations (e.g., bilingual flyers, bilingual radio announcements)
Distrust of government agencies	• Less likely to participate in community outreach activities	• Work with EJ community leaders to increase the credibility of the participatory planning process (FHWA, 1996) • Hire consultants with special expertise working with minority and low-income populations

Table 10.1 Typical Barriers Faced by EJ Communities

Barrier	Resulting Challenges	Example of Overcoming the Barrier
		• Hold public meetings or events in non-governmental (or less traditional) buildings such as schools, churches, and community centers (National Academy of Public Administration, 2001) • Provide opportunities for EJ communities to comment prior to making each decision • Keep the EJ community informed • Reply to EJ public input promptly and respectfully • Involve EJ community leaders in designing the public participation effort (Straus, 1999a)
Limited understanding of how a project will affect their lives and how participation in the process would benefit them	• Need to convince people of their power to influence decisions • Less likely to participate in community outreach activities	• Hold informal meetings early in the process to increase public understanding of how the project may impact the community and why their input is important • Seek public input early in the process and make information available • Involve the EJ communities in decisions that might impact them and in approvals and implementation/Provide opportunities for EJ communities to comment prior to making each decision • Keep the EJ community informed • Reply to EJ public input promptly and respectfully • Hire consultants with special expertise working with minority and low-income populations • Involve EJ community leaders in designing the public participation effort (Straus, 1999a)
Cultural differences	• Techniques need to be adapted to consider how cultural groups interact with one another and make decisions	• Identify preferred community outreach techniques (e.g., in Orange County, California, the open-house format and one-to-one interaction made Mexican-Americans uncomfortable, while informal, small-group meetings increased the participation of Latino neighborhoods) (FHWA, 1996) • Work with local church leaders, school principals, community center staff, and health clinic staff to learn more about cultural factors (National Academy of Public Administration, 2001) and to identify venues for outreach activities (e.g., meetings at churches, schools, libraries, or community service centers, or talking face-to-face at individual homes).

Table 10.2 2000 U.S. Census Data Relating to the Socio-Demographic Characteristics of the EJ Community

Attribute	U.S. Census Product	Lowest Geographic Level	Examples of Variables that Describe the Attribute
Household and family type	Summary File 1 (SF1)	Blocks	QT-P10−Households and families: 2000 (household type, household size, family type and presence of own children)
Mobility	Summary File 3 (SF3)	Block groups	P30−Means of transportation to workers 16+ Years
Disability	Summary File 3 (SF3)	Block groups	P42−Sex by age by disability status by employment status for the civilian non-institutionalized population 5 years and over
Work status (part-time, full-time)	Summary File 3 (SF3)	Block groups	P47−Sex by work status
Education (school enrollment and educational attainment)	Summary File 3 (SF3)	Block groups	P147−School enrollment by level of school by type of school for the population 3 years and over (by race) P148−Sex by educational attainment for the population 25 years and over (by race)
Vehicle availability	Summary File 3 (SF3)	Census tracts	QT-H11−Vehicle available and household income
Language	Summary File 3 (SF3)	Census tracts	DP-2−Profile of selected housing characteristics: 2000 (language spoken at home)

Other sources of information that may assist the transportation agency in understanding the EJ community are:

- county maps illustrating the 1999 per capita program participation produced by the U.S. Department of Agriculture's Food Stamp program (U.S. Department of Agriculture, 2006),
- information on subsidized apartments by city, county, state, and zip code captured by The U.S. Department of Housing and Urban Development (2005),
- tables and thematic maps produced by The Modern Language Association—a private organization—that provides information extrapolated from the 2000 Census on the top 30 languages spoken by the number of speakers in every

county, state, and zip code in the nation (Modern Language Association, 2006), and

- participation data in Adult and Community Education and English as a Second Language (ESL)[20] programs captured by The Department of Education of each state, or county-level information about adult literacy and ESL collected by an equivalent agency.

Finally, it is important for the transportation agency to determine What the community history is, How the EJ community currently receives information, Are there strong religious followings in the community, Are there leaders in the community. By having more knowledge of the typical lives led by people in these communities, the outreach efforts by which they can best be reached become clearer.

10.2 Involving the EJ Community in Designing the Public Participation Effort

The EJ outreach/participation effort will be much more meaningful if principals of collaboration and consensus building are in place. Underlying values, assumptions, and principles of a consensus building approach pertaining to the meaningful involvement of EJ communities are depicted in Box 10.1.

When a proposed toll project is highly controversial, consensus-based approaches can be implemented as a mean to reach unanimous agreements (Carpenter, 1999; Straus, 1999a). By involving the impacted communities in the design of the public participation effort, they might gain a sense of ownership of the effort and be committed to success. The consensus building process can be undertaken by a group of stakeholders which represent different interests and concerns about the issue at hand and want to work

[20] Although the information captured by the Food Stamp and ESL Programs may be too aggregate to inform EJ assessments at the project level, it may serve as a starting point to develop a profile of a community impacted by a toll road project.

together to facilitate its solution (Straus, 1999a). Stakeholders form a process design committee (PDC) witch allows them to (a) work in a collaborative environment from the beginning to the end of the process, (b) deal with conflict situations by recognizing the culture of their constituents, and (c) reach agreement even when dealing with the most difficult issues (Straus, 1999a). This committee develops *a graphic road map* that shows the steps that need to be taken by a much larger set of stakeholders, group, or organization to build consensus on the issues at hand (Straus, 1999a). By using the power of visual representation, the process is organized and managed following a methodical approach. As a result of this road map, participants can visualize who should be involved, key decision points in the process, the different tasks and activities that should occur, and how the final decision will be made. In addition, participants can realize the need for technical experts and facilitation services, and the communication tools necessary to keep the larger community informed on the effort. Finally, this road map helps to ensure that critical questions are raised, considered, and decided, and the definition of success (e.g., agreement on the best solution or decision) is clear for all participants.

Box 10.1 Principles of Collaboration and Consensus Building Pertaining to the EJEM

- A collaborative problem-solving process must include from the beginning to the end all the individuals and groups that are responsible for final decisions, are affected by the decisions, have relevant information or expertise, and have the power to prevent decisions
- Participants must represent different viewpoints and interest, not numbers of people.
- Participants must be able to increase their level of involvement in the process.
- Participants must own the process (i.e., they must be involved in designing the process).
- The process should run phase by phase, with a checkpoint for consensus at the end of each phase.
- The process must educate participants about the issue at hand.
- The process must produce some immediate successes in order to demonstrate that it is legitimate and effective.
- The process must be open and visible.

Source: Adapted from Straus (1999a)

10.3 DEFINING THE GOALS OF THE EJ OUTREACH/PARTICIPATION EFFORT

The next step is to define the goals of the public participation efforts. The goals and what can be gained by them will vary depending on the community and the particular stage in the EJEM (see Chapter 11). This step is imperative since EJ individuals need to understand both the decision-making process and the critical decision points where their input can make a difference.

The transportation agency must be cognizant of the difference between public consultation and public participation (Tyler, 2003). Public consultation implies that the community is, for example, presented a plan with alternatives and then asked for their views and comments. The agency takes these results and then decides which plan to put forward, bearing all of the responsibility for the decision. This is a much more passive way of involving the public and does not necessarily indicate that they have participated in the decision-making. While their views and comments have been considered they essentially have no ownership or responsibility concerning the project decisions. Public participation implies that the community owns the process and therefore, participants are responsible for final decisions and project successes. Principles of collaboration and consensus building applied to public participation efforts equips participants to become better prepared to understand the technical aspects of projects as well as voice their concerns (Strauss, 1999a).

Public participation efforts can also be divided into "inform and involve" techniques (Creighton, 2005). This division is helpful to evaluate participation techniques in terms of specific tasks and to refocus the transportation agency from the typical engineering mindset of "decide and defend." In the case of EJ communities, it is foreseeable that more time will be required "informing" certain EJ communities as the interest in toll projects and the willingness to participate may not come as quickly as in other communities or building the community's capacity to participate in the decision-making process. In these cases, an agency might decide to spend two-thirds of its efforts on "inform" techniques, and then spend the rest of the time and resources on "involve" techniques to ensure better results and a more efficient outcome.

10.4 Identifying and Selecting the Most Appropriate Participation Techniques

Methods for enhancing public participation have advanced to a point where a substantial body of knowledge is found in the literature (Federal Highway Administration, 1996; Susskind et al, 1999; Lawrence, 2003; Creighton, 2005). The author has carefully reviewed various techniques to determine their relevance for involving EJ communities which ensure the meaningful participation of these communities in the decision-making process surrounding toll road projects. In essence, the agency has to consider everything learned about the community and seek techniques that will overcome most of the barriers identified and ensure mutual agreements. These might be:

- proven techniques used in other projects,
- completely new techniques, or
- previously used techniques adapted to overcome the barriers to participation of a specific EJ community

Table 10.3 lists a number of EJ participation techniques and their strengths and weaknesses. For a detailed discussion of various special techniques to enhance public participation, consult the FHWA document entitled "Public Involvement Techniques for Transportation Decision-Making" (Federal Highway Administration, 1996). For a detailed discussion of Deliberative Polling® technique, consult *Deliberative Polling as a Model for ICANN Membership (*Fishkin, J.S., 2006). For a detailed discussion of principles of collaboration and consensus building applied to public outreach techniques, consult the "Consensus Building Handbook: A Comprehensive Guide to Reaching Agreement" (Susskind et at, 1999).

Table 10.3 Public Participation Techniques

Participation Technique	Details	Strengths	Weaknesses
Personalized Involvement			
Walkabouts	• Door-to-door canvassing of neighborhoods • Inform and involve • Opportunities for surveys/interviews • Opportunities to distribute flyers	• Immediate communication with EJ community members • Takes the project and participation opportunities to the EJ communities • More likely to fit into lives of EJ people	• Large time commitment by agency • Relatively small number of people involved
Personalized Letters	• Send letters addressed to specific individuals • Send personal invitations to events • Send personal informative letters	• Makes an impact on community members if they think their opinions are important to the agency • More likely to capture public interest in the project	• Costly • Might not significantly increase attendance at events
Outreach Booths	• Similar to "info booths" • Set up stands at popular locations within the community • Provide information and involve community members	• Brings participation opportunities to the community • Flexible in terms of time and location • May overcome language barriers	• Many people may not take the time to learn about project and get involved
Local Teams			
Create a Local Team	• Teams formed by local community members concerned about the project • Teams help to inform and involve	• Increase attendance at community outreach activities • More personal • Community members relate to other community members better than to agency staff	• Requires substantial resources in terms of time, manpower, and funding • If the community is transitional or too divided, it may be hard to find leaders who are able to bring a strong effort to the community
Meeting Variations			
EJ Public Meetings	• Integrate into the activities people already partake in, such as church activities and community or school events • Increase attendance by having interpreters, refreshments, and staff available to care for children • Multiple meetings at varying times	• Facilitate a large number of community members to get together • Good attendance may produce many results	• Risks low attendance • May not represent full spectrum of EJ community members
Open House	• Similar to public meeting	• Lots of opportunities for	• Risks low attendance

Table 10.3 Public Participation Techniques

Participation Technique	Details	Strengths	Weaknesses
	but no speeches/lectures • Lots of visual aids • Agency staff speaks to attendees on a one-to-one basis • Opportunities to do surveys/interviews	feedback • Overcomes language barriers • Flexible in terms of time • Not as strict as public meeting	• May not represent full spectrum of EJ community members
Deliberative Polling®	• Representative sample of community participates in deliberations about proposed project • Exposed to continuing dialogue with experts and stakeholders • Participants are surveyed before and after deliberations	• Lots of opportunities for feedback • Informed judgments about toll projects	• Requires substantial resources in terms of time, manpower, and funding • Participants are required to meet at a specified location for a significant period of time (e.g., weekend) • Risks low participation if participants are not compensated • Significant number of barriers to participation (e.g., transportation to location, available time, etc.)
School Programs			
Create School Programs	• Programs to educate the children about the project and then parents receive information from children • Parents attend a school event where children present information and parents participate	• Flexible • Far-reaching • Overcomes language barriers • It can be designed to fit the specific community	• Not all community members connected to school
Media			
Using the Media	• Advertise events/information regarding project using the most popular media resources in area: newspaper, radio, TV, flyers, community news boards, etc.	• Flexible • It can reach a lot of people	• It does not guarantee increased involvement • It can be expensive

10.4.1 Personalized Involvement

These types of techniques are particularly relevant for involving EJ communities, as they overcome the barriers of time and access that traditional techniques, such as public meetings, do not. In essence, these techniques require the transportation agency to enter the community and take the public participation effort to the community rather than expecting the community to come to the agency. This technique also demonstrates the agency's concern for the community and will help garner trust and interest in the toll project more than other methods. Some of these techniques include "walkabouts," personalized letters, and outreach booths.

"Walkabouts" are essentially a canvassing of the neighborhoods in the impacted area. Agency staff can go to the streets, and as a result, make the toll road project more tangible to the EJ communities. They can pass out information or advertisements for public participation opportunities. At the same time, these "walkabouts" can also incorporate in-home and on-street interviews with members of the EJ communities, thus combining the "inform" and "involve" tasks. This technique was successfully used in the South Park Avenue improvement project in Tucson, Arizona to involve disadvantaged populations (Federal Highway Administration, 2000).

Personalized letters can be an effective means of communicating with people when many of the EJ community members in the impacted area have permanent addresses. Contacting EJ community members by means of the internet or even telephone may not necessarily be an option as many EJ people might not have access to these resources. It is best to address a letter to a specific person to demonstrate the transportation agency's commitment to the individuals in the community and the agency's desire to get them involved. In the case of widening the South Carolina Route 72, first-class letters were sent by the mayor, and any that were returned undeliverable were delivered in person by the mayor in an effort to involve minority and low-income communities who were not attending other outreach events (Federal Highway Administration, 2000). This made a distinct impression on community members. Handwritten letters show an even more personal touch. Variations on this technique are sending information packets or perhaps a survey. Although the response rate to a mailed survey is typically low, the response rate might be increased if the survey is addressed to a specific person. This technique offers room for creativity and innovation and should be considered to increase public participation in the decision-making process of toll road projects.

Outreach booths can be considered for EJ communities where time is an important barrier to participation. Outreach booths differ from traditional "info booths" in that besides informing the community about a project, public input can also be received, thereby using the time at these booths with EJ people more effectively. By setting up outreach booths at convenient locations, such as shopping malls or grocery stores, at reasonable times, the transportation agency can integrate the outreach effort into the daily lives of EJ community members without overly inconveniencing them. The outreach booths can be used to achieve multiple participation objectives, such as informing and involving the EJ community about the toll road project. For example, interviews or simple polls can be taken at the booths to get an idea of how people feel about the toll road project. These outreach booths could take multiple forms and are more likely to be successful if placed at a location and at a time when people have a few minutes to spare, such as a weekend. Another excellent location would be a large special event in the EJ community. Finally, participation can be increased by making it fun to stop at the booth or perhaps even adding possible incentives, such as food.

10.4.2 Create a Local Team

A common method that proves successful in increasing public concern and consequently participation is the creation of **a local team**. With trust being a common barrier to participation, the EJ community may not be inspired by the efforts of the transportation agency, or they simply might not listen to authoritative groups. They may, however, listen to their friends and neighbors, their minister at church or their child's teacher at school. The challenge then, is how to get these leaders together and take it upon themselves to involve the EJ community in toll road project decisions.

The success of this method varies and it could require substantial resources in terms of time, manpower, and funding. Although the results, if successful, could be tremendous, the risks of failure are unfortunately rather high. Depending on the community, a local team might be very compelling and inspire confidence and concern. However, the community might be too transitional or divided to find leaders who could bring a strong effort to the community. Ideally, the local team should spread the word about the toll road project and the need for community members to participate in the decision process or even spearhead their own participation efforts on behalf of the transportation agency.

10.4.3 Variations on the Traditional Public Meeting

Almost all of the available public participation literature mentions public meetings as one of, if not, the most commonly used technique. Not only are public meetings used often and are therefore well understood, they are also often required by law. It is, however, not the idea to organize a few public meetings and claim that the public participated in the project. This would be unwise, especially in EJ communities, as public meetings potentially overcome few of the barriers to participation faced by these communities. For example, public meetings require community members to attend these meetings at a specified time and location. Also, language and even literacy barriers might not be addressed if there are no alternatives to the main presenter.

Having said this, public meetings can still be effective if they are viewed with a different perspective and adapted to overcome the barriers faced by EJ communities (i.e., **EJ Public Meetings**). Ideally, public meetings provide a forum for a larger number of community members to get together and participate than do the personalized involvement techniques. Given the day-to-day challenges of EJ community members, it is, however, recommended that the public meeting is somehow integrated into the activities EJ people already partake in, such as church activities and community or school events. Also, attendance can potentially be increased by having interpreters, refreshments, and staff available to care for children. At the same time, EJ public meetings can be structured differently. Traditionally, these meetings have been "closed," meaning they took place over a couple of hours and participants had to stay the entire time to hear the information and participate in the meeting. A different, more EJ-friendly version is to have an "open" meeting over a period of time, where people are free to come and go. This version is more like the format of an open house.

The **Open House** is a more social version of the traditional public meeting by allowing community members to interact with agency representatives on an individual basis. The latter is a means to overcome language and literacy barriers if agency staff is fluent in the languages spoken by the EJ community members. Also, having agency staff available to talk to the EJ community on an individual basis removes the need for someone to have to read a poster or pamphlet, for example. The format of an open house can therefore be adapted to fit the needs of the specific EJ community and help make participants feel more involved than a traditional public meeting, which tends to take the format of present and respond. The challenge again is timing and location. Multiple open houses might be effective and, although more time consuming, might result in increased participation. The key is to consider the schedules of EJ community members and integrate the open house into their schedules, resulting in more participation.

Deliberative Polling® (2006a), a technique developed by Professor James Fishkin at The University of Texas at Austin, has shown to be especially suitable for obtaining input regarding issues the public may have little knowledge of. To achieve both representation and deliberation, Deliberating Polling® combines sample surveys and focus groups into a powerful technique for gauging informed public opinion. Representatives of a population are surveyed, and opportunities are provided for residents to become informed on the issues in which they will be consulted and to voice their concerns (Fishkin, 2006). Polling not only educates participants, but helps them become well-informed citizens who can think about complex issues (Center for Deliberative Polling, 2006b).

Face-to-face Deliberating Polling® is recommended to educate EJ populations about potential impacts a toll road project may have on their trips and communities (relative to a non-toll road) and potential mitigation options to reduce or eliminate any identified disproportionately high impact. The recommended process, adapted by the process recommended by The Center for Deliberative Polling® is as follow:

- First, prepare a list of *Potential EJ Stakeholders*. This list should include presidents of neighborhood associations, religious/community leaders, school district officials, environmental group leaders, leaders of charity organizations, local government representatives, local health officials, and any other recognized EJ leader.
- Second, take a representative random sample from the list of *Potential EJ Stakeholders*. Invite them to gather at a single place during an entire weekend

to discuss EJ concerns surrounding toll road projects. Beforehand, send the stakeholders briefing materials to explain the need and purpose of a toll road project. Make these materials available to the entire EJ community as well. Identify a convenience place to meet the stakeholders. Provide transportation to those that need it. Set meeting days and times based on stakeholders availability.

- Third, during the weekend, involve the *Engaged EJ Stakeholders* (those who accepted to participate) in a continuing dialogue with competing experts and decisions-makers based on questions they develop in focus groups discussions regarding (a) additional impacts a toll road project may have on the community compared to a non-toll road project and (b) effective mitigation options to lessen or eliminate identified disproportionately high or adverse effects. It is particularly important that the *Engaged EJ Stakeholders* understand the importance of sharing their concerns so the transportation agency can take actions to eliminate or reduce any disparity.
- Finally, at the end of the weekend deliberations, the stakeholders are asked the same questions again. At this stage, it is expected that the *Engaged EJ Stakeholders* can make an informed judgment on the toll road issue. The resulting changes in opinion will represent the conclusions the public would reach if they had a better opportunity to become more informed about toll road impacts and mitigation options.

10.4.4 School Programs

School programs are a commonly used technique and have proven to be quite effective in encouraging minority and low-income populations to participate. By using schools and the children of the community as resources, it is possible to overcome multiple barriers faced by EJ communities, including language and literacy. It also fits into the everyday lives of the families.

There are numerous ways the transportation agency could work with community schools to effectively encourage the participation of EJ communities. Schools can be used as an avenue to educate the children about the toll road project and then in return inform their parents about the project by having them take home information about the toll road. Parents can be asked to attend children's presentations about the toll project and then provide their feedback about the toll road. A good example where schools formed an important component of the public participation efforts to a transportation project was the Verona Road and West Beltline Needs Assessment Study in Wisconsin. The project team worked with students from the Akira Toki Middle School to inform and involve minority and low-income community members (Federal Highway Administration, 2000).

Using school programs as a part of the EJ participation plan is not only effective and far reaching in terms of EJ community members exposed to the toll project, it is also very flexible. A school program can be designed to fit the specific school and community and blend into the lives of the students and families without requiring a major effort or time commitment from participants. Additional contact can be made with EJ community members at Parent Teacher Association (PTA) meetings, when family members are already attending the school or following parent-teacher meetings. In the worse case, children can be educated about a transportation investment, such as toll roads, that they probably would not have learned about otherwise and at least bring the topic to the parents' attention by telling them about it. This technique, however, does bias the public participation effort to EJ community members with children or grandchildren in local schools. Although it might be less of a concern in EJ communities as large, multi-generational families are often more common, it should not be assumed that all EJ community members would have a link to the local schools.

10.4.5 Using the Media

The many forms of the media are a common way for individuals, including EJ communities, to hear about what is happening in their communities. The media can be used in many ways, from formal advertising to encouraging the local paper to run articles about the proposed toll project. The transportation agency should, however, determine the frequency with which people read newspapers, as some EJ communities might not have high newspaper subscription rates and therefore a small number of people that read the paper. Radio and television advertisements are also options, but they tend to be substantially more costly than simpler methods, such as flyers in grocery bags or bulletins on community news boards at churches. The transportation agency should make an earnest effort to identify the most appropriate media resources to inform the EJ community about the toll project and any planned outreach efforts.

When using media advertisements, it is important that the transportation agency provide an appropriate contact number. The agency must make it clear to the EJ community that their input regarding the toll road project is highly desired and even if they cannot attend the participation events they can contact the agency. Phone numbers, e-mail, and mailing addresses, as well as comment boxes in different locations around the EJ community where people can drop off letters or notes, must be made available. By providing as many opportunities as possible for EJ community members to contact the transportation agency, confidence and trust will be instilled within the EJ community that the transportation agency cares about the community's contributions and have their interests at heart.

10.5 Planning, Implementing, and Evaluating the Selected Participation Technique(s)

While the transportation agency might experience some level of success by simply getting the EJ community together and informing them about the toll project and getting basic feedback, the process will be much more meaningful when dedicated and well performed management strategies are in place. EJ outreach/participation effort requires careful planning, organization and preparation, especially when participants come from different ethnic, racial, religious, and economic backgrounds or they disagree on the best solution or decision.

Each of the public participation techniques listed in Table 10.3 will have specific management requirements, but there are several general concepts to keep in mind. First, everything about the technique and the subsequent participation event needs to be well thought out and planned ahead of time. Any disorganization, down to the setup of seating or the position of posters, can lead to wasted time and effort on the day of the event. Second, the location must be well prepared. Handout materials must be ready and translated into the languages spoken in the EJ community if English is not the only language spoken. Third, staff must be well trained and prepared in terms of what they have to say and questions to ask to give the best impression to the EJ community and extract the most useful contributions from those attending. Facilitators and mediators play an important role in enhancing participants' chances of reaching agreement when dealing with conflicting situations (Carpenter, 1999). Fourth, time management is essential, and allotting time for different components of the event will be helpful in making the best use of the little interaction time the agency staff typically will have with those participating. Finally, consensus building techniques should be applied when seeking unanimous agreement.

Straus (1999b) describes how to plan for and run a successful meeting so that participants focus on the substance of a problem and steadily work together toward consensus. Setting up meetings for success when dealing with conflicting situations requires carefully planning every factor that influences the meeting outcome. Meeting planners must understand and make decisions about the purpose of the meeting and who should be involved. They must also consider how the desired outcomes, agendas, and roles and responsibilities of participants and organizers affect the overall outcome. Lastly, meeting planners should consider the ground rules that will guide discussions, the group decision to be made and the meeting location. During the meeting, facilitators can use their skill and attitudes (e.g., believe in the possibility of consensus, and value diversity and conflict) to run the meeting in a way that allows participants to focus on the core of the issue—which is to progressively work together toward consensus. For example, by understanding the organizational culture of the participants, facilitators can set ground rules and procedures that reflect different cultural expectations and problem-solving styles (Carpenter, 1999).

Finally, the transportation agency should evaluate the effectiveness of its public outreach activities. Regardless of the selected participation technique, in managing and implementing the technique, the transportation agency should keep the public informed; fully engage with members of the EJ communities who show interest in the project, even with the opponents; maintain flexibility regarding public involvement; assembled the necessary teams of skilled professionals; respond fully to all comments, and show what was gained from past public participation efforts and how it affected the project outcome.

In this regard, the effectiveness of the selected participation technique(s) should be evaluated (see Box 10.2), especially when reaching out to EJ communities, as one of the key issues is to build trust between the agency and the community.

Box 10.2 Evaluation Measures
• What type of participation technique(s) was used? • How many people participated in the outreach effort? • How many of those participants were from traditionally underrepresented population groups (e.g., minorities, low-income individuals, people with disabilities, elderly)? • Were communication materials adapted to the needs of the (EJ) population groups? • How was public input incorporated into the decision-making process? Is there evidence of the degree to which (EJ) public input influences the process and changed the outcome? • How were (EJ) public informed of the results of the public involvement process?

Source: Adapted from Northwestern Indiana Regional Planning Commission (2005)

10.6 CONCLUDING REMARKS

One of the core principles of Environmental Justice (EJ) analysis is the "meaningful" involvement of potentially impacted minority and low-income communities in the decision-making process surrounding the proposed investment. This research outlines a general approach to ensure meaningful EJ public participation at each step of the EJ Evaluation Methodology (EJEM) as follows:

- Understanding the EJ community.
- Involving the EJ community in designing the public participation effort.
- Defining the goals of the EJ outreach/participation effort.
- Identifying and selecting the most appropriate participation technique(s).
- Planning, implementing, and evaluating the selected participation technique(s).

Understanding the impacted EJ communities is essential to ensure that selected public participation techniques fit into lives and culture of the community and, with proper management, get the most useful results.

The EJ outreach/participation effort will be much more meaningful if principals of collaboration and consensus building are in place. By involving EJ participants in the design of the public participation effort, they gain a sense of ownership of the effort and therefore, they will be committed to success. Consensus-based techniques will also aim EJ participants to become better prepared to understand toll road technical issues and argue their concerns.

Defining the goals for the public participation efforts is imperative since EJ individuals should understand the decision-making process and the critical decision points where their input can make a difference. The goals and what can be gained will vary depending on the community and the particular stage in the EJEM. Methods for enhancing public participation have advanced to a point where a substantial body of knowledge is found in the literature. The author has carefully reviewed various techniques to determine their relevance for involving and informing EJ in the decision-making process. When selecting a public participation technique(s), the analyst has to consider everything learned about the community and select a technique(s) that will (a) overcome most of the barriers to participation of the specific EJ community and (b) ensure mutual agreements.

While the transportation agency might experience some level of success by simply getting the EJ community together and informing them about the toll project and getting basic feedback, the process will be much more meaningful when dedicated and well performed management strategies are in place. EJ outreach/participation effort requires careful planning, organization and preparation, especially when participants come from different ethnic, racial, religious, and economic backgrounds or they disagree on the best solution or decision. Although each of the public participation techniques listed in this research will have specific management requirements, there are several general concepts to keep in mind.

Finally, the transportation agency should evaluate the effectiveness of its public outreach activities by showing EJ participants what was gained from past public participation efforts and how it affected the project outcome. This is especially important when reaching out to EJ communities, as one of the key issues is to build trust between the agency and the community.

Chapter 11 Effective EJ Participation Component

The overall objective of the Environmental Justice (EJ) Participation Component is to ensure meaningful representation and participation of minority and low-income populations in the decision-making process of the planned toll road project. EJ outreach efforts are foreseen in various stages of the EJ Evaluation Methodology (EJEM) to ensure that (1) all EJ communities (neighborhoods) are identified and given the opportunity to participate in a meaningful way, (2) all the adverse impacts are identified and prioritized, (3) the measured impacts are shared with the impacted EJ communities, and (4) effective mitigation options to lessen or offset identified disproportionately high or adverse impacts are designed in consultation with the impacted EJ communities. This chapter presents the goals of the EJ outreach effort at each step of the EJEM.

11.1 Who Would be Impacted?/Is there a Potential EJ Concern?

EJ communities should be invited to participate in the decision-making process of toll road projects as early as possible. The goals of the EJ outreach effort during this step of the EJEM are the following:

- To identify all potentially impacted neighborhoods, including their history and values
- To validate the spatial concentrations of EJ populations within the impacted area which should include all potentially impacted neighborhoods
- To identify potential "avenues" that can be used to distribute information about the proposed toll project to the potentially impacted minority and low-income communities
- To obtain input from those who can speak on behalf of the entire EJ community. In other words, identify and engage individuals who can represent

the views of the impacted EJ communities, such as presidents of neighborhood associations, religious/community leaders, school district officials, environmental group leaders, leaders of charity organizations, elected local government representatives, and local health officials.

- To identify the most appropriate participation technique(s) for informing and involving the impacted EJ communities (e.g., personal interviews, formal meetings, informal meetings, focus groups, telephone surveys, and mail questionnaires).
- To identify the EJ community barriers for managing and implementing the selected participation techniques (e.g., preferred language(s) of communication, childcare arrangements, and transportation provision for those who do not have means to get to the meeting places).
- To identify strategic locations for liaising with EJ communities to ensure participation efforts span all of the potentially impacted EJ communities.

Depending on the impacted community, personal interviews, a telephone survey, and or personalized letter and mail survey might be appropriate participation technique(s) to contact and engage EJ individuals and community-based organizations (e.g., neighborhoods, churches, schools) who can represent the views of the impacted EJ community.

By contacting the EJ communities early on, the transportation agency will gain a better understanding of whether there is a potential EJ concern and how to inform and involve minority and low-income populations in the subsequent steps of the EJEM.

11.2 What are the Additional Impacts of Concern Imposed by the Toll Road versus the Non-Toll Road?

The goals of the outreach effort during this step of the EJEM are the following:

- To inform the EJ community about the proposed toll road project (educate the community) and
- To involve the community by obtaining their views and concerns about how the proposed toll project will impact their trips and community.

It is imperative that the EJ community and representatives of the community be educated about the proposed toll project and gain an understanding of the potential impacts to ensure an informed and meaningful discussion and prioritization of the impacts of concern surrounding toll roads relative to non-toll roads. The EJ assessment of toll road projects is especially complex, because toll roads may impose substantial burdens as well as benefits to the EJ communities compared to non-toll roads. For example, the conversion of an existing non-toll road into a toll road may have a disproportionate impact on low-income drivers if they have to shift to congested roads to get to their workplaces to avoid the toll. On the other hand, local minority communities may benefit from the conversion and operation of a non-toll road into a toll road if they receive a share of the jobs and contracts generated by this change. Furthermore, EJ people might be unsure of how a toll road may impact them, especially if they do not have their own cars and tend to use public transportation. Obviously, benefits and burdens imposed by a toll road project on EJ communities cannot be generalized and should be examined at the project level.

Once the communities understand the technical issues and can articulate their views and concerns, meaningful and informed participation can be accomplished. At this stage, EJ people should thus be in a position to articulate how they think the proposed toll road would impact their activity space (i.e., the places where they work, shop, and partake in other activities) and communities.

A number of avenues exist to share information about the proposed toll project, such as personalized letters, outreach booths, church bulletins, neighborhood organization newsletters, public meetings, open houses, and the media. On the other hand, focus groups, mail questionnaires, personal interviews, and walkabouts can be used to obtain the input of potentially impacted EJ communities.

The EJ input received during this step of the EJEM may be used by the transportation agency to finalize and prioritize the additional impacts associated with the toll road relative to the non-toll road. As indicated in Chapter 6, the *Toll Road Impact Matrix* may be used by the transportation agency as a reference when identifying the additional benefits and burdens associated with the toll road condition (alternative 2) as compared to the non-toll road condition (alternative 1). Based on the EJ community input and engineering analysis, a *Comprehensive Toll Road Impact Matrix* that represents all EJ concerns can be prepared. This matrix can be used to quantify and or qualitatively describe the additional impacts (both benefits and burdens) that minority and low-income populations are most likely to experience as a result of the proposed toll road project. This matrix will also provide the basis for a two-way communication between the agency and the EJ community when designing the mitigation options.

11.3 ARE THE EJ COMMUNITIES DISPROPORTIONATELY IMPACTED BY THE TOLL ROAD?/WHAT ARE POTENTIAL MITIGATION OPTIONS?

The goals of the EJ outreach effort during this step of the EJEM are the following:

- to inform (educate) the EJ community about the magnitude of the additional impacts (benefits and burdens) associated with the proposed toll road project compared to the non-toll road and

- to involve the EJ community in the conceptualization and design of acceptable options to avoid, minimize, or mitigate any disproportionate impact on the community.

The transportation agency should thus present up front the measured benefits and burdens imposed by the toll road condition (relative to the non-toll road condition) on the EJ communities calculated in steps 4 (What is the magnitude of the additional impacts?) and 5 (Are the EJ communities disproportionately impacted by the toll road?) of the analytical component of the EJEM. Table 11.1 presents a list of performance measures to communicate to the impacted community the benefits and burdens of the toll road condition relative to the non-toll road condition. The table also highlights the simplicity and clarity of these measures in terms of communicating and sharing them with the community.

Table 11.1 Environmental Justice Performance Measures

<table>
<tr><th>Impact</th><th>Performance Measures</th><th>Simplicity and Clarity*</th></tr>
<tr><th colspan="3">Physical Environmental Quality</th></tr>
<tr><td rowspan="3">Air pollution (health effects)</td><td>Carbon Monoxide (CO)</td><td rowspan="3">Geared for technical audience</td></tr>
<tr><td>Particulate (PM_{10}, $PM_{2.5}$)</td></tr>
<tr><td>Ozone (O_3)</td></tr>
<tr><td>Traffic Noise</td><td>Noise levels (dB)</td><td>Easy for public to relate to</td></tr>
<tr><th colspan="3">Mobility and Safety Impacts</th></tr>
<tr><td rowspan="7">Access to work, shopping, sensitive sites (health care centers and educational facilities), and recreational places</td><td>Number of jobs accessible by auto/transit within a specific travel time threshold</td><td>Varies, for technical audience</td></tr>
<tr><td>Number of educational facilities accessible by auto/transit within a specific travel time threshold</td><td>Varies, for technical audience</td></tr>
<tr><td>Number of healthcare facilities such as hospitals and nursing homes accessible by auto/transit/foot within a specific time span</td><td>Varies, for technical audience</td></tr>
<tr><td>Number of shopping centers accessible by auto/transit within a specific travel time threshold</td><td>Varies, for technical audience</td></tr>
<tr><td>Number of recreational facilities such as parks, playgrounds, and pools, accessible by auto/transit within a specific travel time threshold</td><td>Varies, for technical audience</td></tr>
<tr><td>Walk to transit (e.g., number of bus stops within a ¾ mile radius)</td><td>Varies, for technical audience</td></tr>
<tr><td>Walk to community facilities (e.g., number of schools, libraries, hospitals, and senior centers within a ¾ mile radius)</td><td>Varies, for technical audience</td></tr>
<tr><td rowspan="2">Bicycle use</td><td>Changes in the number of injuries</td><td rowspan="2">Easy for public to relate to</td></tr>
<tr><td>Changes in bicycle access</td></tr>
<tr><td rowspan="2">Pedestrian use</td><td>Changes in the number of injuries</td><td rowspan="2">Easy for public to relate to</td></tr>
<tr><td>Changes in pedestrian access</td></tr>
<tr><th colspan="3">Social and Economic Impacts</th></tr>
<tr><td rowspan="3">Displacement of residential properties</td><td>Number of (temporary/permanent) displaced residents</td><td>Easy for public to relate to</td></tr>
<tr><td>Number of (temporary/permanent) displaced homes</td><td>Easy for public to relate to</td></tr>
<tr><td>Value of displaced homes</td><td>Easy for public to relate to</td></tr>
<tr><td rowspan="3">Neighborhood cohesion, social interaction</td><td>Changes in the number of households within neighborhoods</td><td>Public can relate to</td></tr>
<tr><td>Average length of displaced residents in their neighborhood</td><td>Public can relate to</td></tr>
<tr><td>Number of displaced residents with at least one relative in their neighborhood</td><td>Public can relate to</td></tr>
</table>

Table 11.1 Environmental Justice Performance Measures

Impact	Performance Measures	Simplicity and Clarity*
	Number of residents working within a specific distance of their neighborhoods	Public can relate to
	Changes in community support activities (e.g., residents provide child care and transportation to one another)	Public can relate to
Neighborhood traffic patterns and safety	Changes in vehicle volumes on local streets	Understood by most audiences
	Changes in truck volumes on local streets	Understood by most audiences
	Changes in traffic delays on local streets	Understood by most audiences
Cultural resources	Number of displaced landmarks and gathering places	Suitable for specific audiences
Aesthetics	Number of parks and their recreation activities	Easy for public to relate to
	Changes in trees or green areas	
	Changes in the quality and use of waterways	
Displacement of local businesses	Number of displaced businesses	Public can relate to
	Value of displaced businesses	Public can relate to
Business access and deliveries	Number of local businesses accessible by auto/transit within a specific travel time threshold	Varies, for technical audience
Local employment/job creation/job types	Number of displaced jobs	Public can relate to
	Changes in employment opportunities for local residents	
	Changes in type of jobs available for local residents	
Land, commercial and residential property values	Changes in land, commercial, and residential property values	Public can relate to
Tax revenues	Changes in tax revenues	Varies, for technical audience
Income/Financial household	Average travel cost per mile per auto users	Public can relate to
	Average travel cost per mile per transit users	

**Source: Adapted from Turner et al. (1966)

Given the additional benefits and burdens that minority and low-income populations are more likely to experience as a result of the proposed toll road project, the performance measures by EJ concentration zones (i.e., *EJ indexes*) should be shared with the EJ community. Chapter 7 explains the calculation of a number of *EJ indexes* that can be used to assess impacts on accessibility, air and noise quality, residential and commercial property values, and pedestrian and bicycle safety imposed by toll roads (relative to non-toll roads) on impacted EJ communities. The results of the quantitative approach for measuring and comparing the magnitude of the additional impacts imposed by the toll road condition relative to the non-toll road condition (i.e., vertical comparison shown in Figure 7.2) should be shared with the community in terms of 'benefits', 'burdens' or 'no effect' (see Boxes 11.1, 11.2, 11.3, 11.4 and 11.5). The explanation of the statistically significant and no significant findings should focus on the difference of the measured impacts between the toll-road condition (alternative 2) and the non-toll road condition (alternative 1). That is, when the analyst fails to reject that there is no difference between the measured impacts (at a α significant level), the community should be informed that the difference is almost zero (or close to zero) and therefore the toll road condition will have the same effect on the community relative to the non-toll road condition. On the other hand, when the findings are statistically significant (i.e., the analyst can reject the null hypothesis at a α significant), the community should be informed that there is a substantial difference between the two conditions and as a result the toll road project will burden (or benefit) the community relative to the non-toll road project.

Box 11.1 Sharing with the EJ Community the Magnitude of the Physical Environmental Quality Impacts

	EJ Physical Environmental Quality Indexes by EJ Concentration Zones	
	Air Quality	**Traffic Noise**
Non-toll road condition (alternative 1)	AQI_g^1	NQI_r^1
Vertical Comparison	$\updownarrow$	$\updownarrow$
Toll road condition (alternative 2)	AQI_g^2	NQI_r^2
Difference	$d_g = AQI_g^2 - AQI_g^1$	$d_r = NQI_r^2 - NQI_r^1$
Interpretation of the Difference*	Burden if $d_g >> 0$	Burden if $d_r >> 0$
	No impact if $d_g \approx 0$	No impact if $d_r \approx 0$
	Benefit if $d_g << 0$	Benefit if $d_r << 0$
Sharing the results with the community (example):	Because $d_i >> 0$, the toll road condition will burden the community in zones (neighborhoods) with medium concentration of EJ population by increasing the concentrations of Carbon Monoxide (CO) relative to the non-toll road condition Because $d_i \approx 0$, the toll road condition has no impact on the concentrations of Carbon Monoxide (CO) relative to the non-toll road condition in zones (neighborhoods) with high concentration of EJ population Because $d_i << 0$, the toll road condition will benefit the community in zones (neighborhoods) with medium concentration of EJ population by decreasing the concentrations of Carbon Monoxide (CO) relative to the non-toll road condition	

*Based on the results from the statistical and power analysis.

Box 11.2 Sharing with the EJ Community the Magnitude of the Measured Mobility Impacts

	EJ Mobility Indexes by EJ Concentration Zones				
	Accessibility to Work	**Accessibility to Educational Facilities**	**Accessibility to Health Care Facilities**	**Accessibility to Shopping Facilities**	**Accessibility to Recreational Facilities**
Non-toll road condition (alternative 1)	W_i^1	E_i^1	H_i^1	S_i^1	S_i^1
Vertical Comparison	$\updownarrow$	$\updownarrow$	$\updownarrow$	$\updownarrow$	$\updownarrow$
Toll road condition (alternative 2)	W_i^2	E_i^2	H_i^2	S_i^2	S_i^2
Difference	$d_i = W_i^2 - W_i^1$	$d_i = E_i^2 - E_i^1$	$d_i = H_i^2 - H_i^1$	$d_i = S_i^2 - S_i^1$	$d_i = R_i^2 - R_i^1$
Interpretation of the Difference	Benefit if $d_i >> 0$				
	No impact if $d_i \approx 0$				
	Burden if $d_i << 0$				
Sharing the results with the community (example):	Because $d_i >> 0$, the toll road condition will benefit the community in zones (neighborhoods) with high concentration of EJ population by increasing the number of jobs accessible by car within 30 minutes relative to the non-toll road condition Because $d_i \approx 0$, the toll road condition has no impact on the number of jobs accessible by car within 30 minutes relative to the non-toll road condition in zones (neighborhoods) with high concentration of EJ population Because $d_i << 0$, the toll road condition will burden the community in zones (neighborhoods) with high concentration of EJ population by decreasing the number of jobs accessible by car within 30 minutes relative to the non-toll road condition				

*Based on the results from the statistical and power analysis.

Box 11.3 Sharing with the EJ Community the Magnitude of the Measured Job Accessibility Impact (Example)

A transportation agency is considering the conversion of a planned non-toll road into a toll road prior to the opening of the road to the public. To assess whether a disproportionate impact will be imposed, access to employment by EJ concentration zone has been estimated using TransCAD. The table below shows the number of employment opportunities that can be reached within 30 minutes by car in zones with high concentrations of minority and low-income populations given the two alternatives.

	Number of jobs accessible within 30 minutes by car		
Zones with high concentrations of EJ populations	Toll road condition (W_i^2)	Non-toll road condition (W_i^1)	Difference (d_i)
1	19	15	4
2	21	20	1
3	18	22	-4
4	5	8	-3
5	34	25	9
6	12	17	-5

The data analysis reveals that the number of employment opportunities accessible within 30 minutes by car in zones with high concentrations of EJ populations is almost the same given the toll road and non-toll road condition.

Box 11.4 Sharing with the EJ Community the Magnitude of the Measured Social and Economic Impacts

	Social and Economic EJ Indexes by EJ Concentration Zones	
	Land and Commercial Property Values	**Land and Residential Property Values**
Non-toll road condition (alternative 1)	$CPVI_g^1$	$RPVI_g^1$
Vertical Comparison	$\updownarrow$	$\updownarrow$
Toll road condition (alternative 2)	$CPVI_g^2$	$RPVI_g^1$
Difference	$d_g = CPVI_g^2 - CPVI_g^1$	$d_g = RPVI_g^2 - RPVI_g^1$
Interpretation of the Difference	Benefit if $d_g >> 0$	
	No impact if $d_g \approx 0$	
	Burden if $d_g << 0$	
Sharing the results with the community (example):	Because $d_g >> 0$, the toll road condition will benefit the residents in zones (neighborhoods) with high concentration of EJ population by increasing their residential property values relative to the non-toll road condition Because $d_g \approx 0$, the toll road condition has no impact on the residential property values relative to the non-toll road condition in zones (neighborhoods) with high concentration of EJ population Because $d_g << 0$, the toll road condition will burden the residents in zones (neighborhoods) with high concentration of EJ population by decreasing their residential property values relative to the non-toll road condition	

*Based on the results from the statistical and power analysis.

Box 11.5 Sharing with the EJ Community the Magnitude of the Measured Safety Impacts

	Safety EJ Indexes by EJ Concentration Zones	
	Pedestrian Danger Index	**Bicycle Safety Index**
Non-toll road condition (alternative 1)	PDI_i^1	BSI_s^1
Vertical Comparison	$\updownarrow$	$\updownarrow$
Toll road condition (alternative 2)	PDI_i^2	BSI_s^2
Difference	$d_i = PDI_i^2 - PDI_i^1$	$d_s = BSI_s^2 - BSI_s^1$
Interpretation of the Difference	Burden if $d_i >> 0$	Burden if $d_s >> 0$
	No impact if $d_i \approx 0$	No impact if $d_s \approx 0$
	Benefit if $d_i << 0$	Benefit if $d_s << 0$
Sharing the results with the community (example):	Because $d_i >> 0$, the toll road condition will benefit the community in zones (neighborhoods) with high concentration of EJ population by increasing pedestrian safety relative to the non-toll road condition Because $d_i \approx 0$, the toll road condition has no impact on the pedestrian safety relative to the non-toll road condition in zones (neighborhoods) with high concentration of EJ population Because $d_i << 0$, the toll road condition will burden the community in zones (neighborhoods) with high concentration of EJ population by decreasing the pedestrian safety relative to the non-toll road condition	

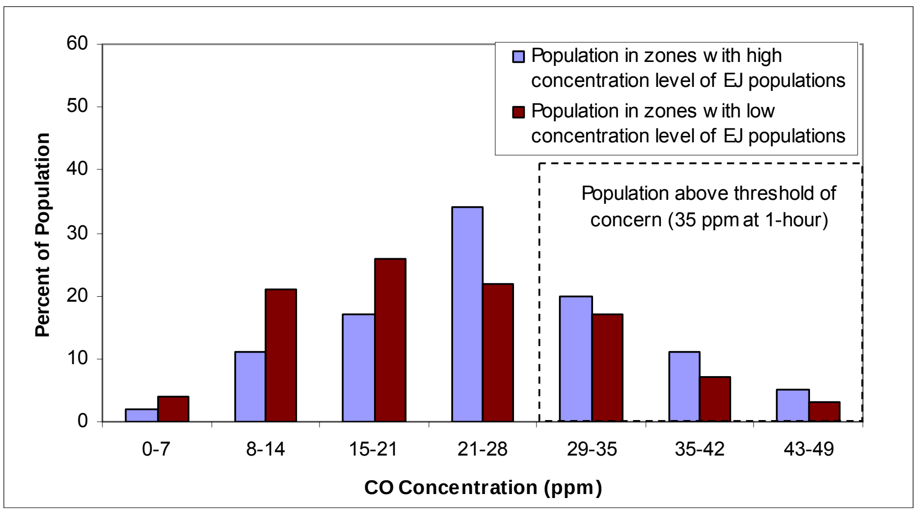
*Based on the results from the statistical and power analysis.

The results of the quantitative approach for measuring and comparing the magnitude of the impacts imposed by the toll road condition in zones with high and medium concentrations of EJ populations relative to zones with low concentrations of EJ populations (i.e., horizontal comparison shown in Figure 7.2) should be shared with the community in terms of ‘benefits’, ‘burdens’ or ‘no effect’ as suggested in the examples provided in Boxes 11.6 and 11.7. Given the measured impacts, the explanation of the statistically significant and no significant findings should focus on the magnitude of the two (independent) means or two (independent) population proportions. That is, when the findings are not statistically significant (i.e., the analyst fails to reject the null hypothesis at a α significant level), the community should be informed that the two means/two population proportions are similar in magnitude (or have similar values) and therefore the toll road condition will have the same effect on zones with high, medium, and low concentrations of EJ populations. On the other hand, when the findings are statistically significant (i.e., the analyst can reject the null hypothesis at a α significant level), the community should be informed that the toll road project will benefit/burden the zones with high/medium concentrations of EJ populations relative to zones with low concentrations of EJ populations because the measured impacts (represented by the two means/two population proportions) differ considerably in magnitude.

Box 11.6 Sharing with the EJ Community the Magnitude of the Air Quality Impacts Imposed by the Toll Road Condition (Example)

A transportation agency is considering the conversion of an existing non-toll road into a toll road by tolling the existing lanes and adding adjacent frontage roads as *free alternatives*. An air quality analysis using CALRoads View reveals that neighborhoods adjacent to the frontage roads will be exposed to high concentrations of carbon monoxide (CO). The affected population groups by EJ concentration levels have been identified by overlaying the EJ concentration zones in the impacted area with the pollution surfaces (see Table and Figure below).

CO Concentrations at 1-hour (ppm)	Population by EJ Concentration Level	
	High	**Low**
0-7	269	169
8-14	1,477	888
15-21	2,282	1,100
21-28	4,565	931
29-35	2,685	719
35-42	1,477	296
43-49	671	127
Total	**13,425**	**4,230**



	Population by EJ Concentration Level	
	High	**Low**
Total population in the impacted area = (1)	13,425	4,230
Population affected by CO concentrations > 35 ppm at 1-hour = (2)	4,833	1,142
Population proportions = $\frac{(1)}{(2)} x100$	36%	27%

The data analysis revealed that the percentage of people impacted by poor air quality (i.e., CO concentrations exceeds the standard) in zones with high concentration of EJ populations is higher than that for zones with low concentration of EJ populations.

*Based on the results from the statistical and power analysis.

Box 11.7 Sharing with the EJ Community the Magnitude of the Traffic Noise Impacts Imposed by the Toll Road Condition (Example)

A transportation agency is considering the conversion of an existing non-toll road into a toll road by tolling the existing lanes and adding adjacent frontage roads as *free alternatives*. A traffic noise quality analysis using FHWA's TNM reveals that receivers adjacent to the frontage roads will be exposed to noise levels that exceed the federal's noise abatement criteria (i.e., 67 dBA). The affected population groups by EJ concentration levels have been identified by overlaying the EJ concentration zones in the impacted area with the model results (see table below). Do the data suggest that the proportion of population (at receivers) impacted by excessive traffic noise in zones with high EJ concentration levels is higher than that for zones with low EJ concentration levels at a 0.05 significance level?

	EJ Concentration Zones	
	Medium	**Low**
Total population in the study area	13,230	8,425
Population exposed to noise level > 67 dbA	4,197	3,422
Population proportions = $\frac{(1)}{(2)} x100$	45%	41%

The data analysis revealed that the percentage of people impacted by excessive traffic noise (i.e., noise levels that exceed the FHWA's noise abatement criteria) in zones with medium concentration of EJ populations is higher than that for zones with low concentration of EJ populations.

*Based on the results from the statistical and power analysis.

EJ communities should be active in the decision-making process, including problem solving to mitigate or remediate the disproportionate adverse impacts the toll road may have on their communities. Once the EJ communities have gained an understanding of how they will potentially be burdened by the toll road, potential actions to mitigate or offset the identified burdens (see Chapter 8) should be shared with the impacted community. The EJ input received during this step of the EJEM should be used by the transportation agency to design an *EJ Mitigation and Enhancement Plan* that represents both community input and engineering analysis.

Ultimately, the *EJ Mitigation and Enhancement Plan* should help ensure that the toll road project is designed, built, and operated without disproportionate disruption to the EJ community. Crucial elements of this plan are the following:

- all reasonable measures (e.g., prevention, amelioration, rehabilitation, restoration, compensation, enhancement, local benefits) to minimize or avoid any disproportionate impact on impacted EJ communities (see example provided in Box 11.8);
- provisions to integrate individual measures into an action plan;
- monitoring guidance (e.g., compliance, mitigation effectiveness, public concerns);
- links between monitoring and baseline analysis, impact prediction, and mitigation; and
- provisions to monitor cumulative effects.

The mitigation plan should not be envisioned as the end of the EJEM. The addition of monitoring and management step partially addresses whether the primary purposes of the EJ assessment of a toll road project is achieved or not. The inclusion of an auditing step makes it possible to address broader environmental output questions, such as the accuracy of the impacts forecast and the effectiveness of the EJ assessment, including the actions to mitigate any disproportionate impact.

Box 11.8 Sharing with the EJ Community the Magnitude of the Mitigated Impacts (Example)

A transportation agency is considering the conversion of an existing non-toll road into a toll road by tolling the existing lanes and adding adjacent frontage roads as *free alternatives*. The analysis of the magnitude of the additional impacts revealed that EJ populations would be disproportionately burdened by this conversion. Actions to mitigate these disproportionate adverse impacts were conceptualized and designed based on the EJ community input and engineering analysis. The mitigated impacts (see Table below) will help ensure that the planned conversion will be designed, built, and operated without disproportionate disruption to the EJ community.

EJ Burden (Step 5)	Potential Mitigation Options (Step 6)	Measured Impact: Before mitigation (Step 4)	Measured Impact: After mitigation (Step 5 + Step 6)	Comment
Increase Carbon Monoxide (CO) and particulate (PM10, PM2.5) at frontage roads	Ban heavy vehicles from frontage roads Traffic signal coordination at frontage roads	√	√	Meet and exceed the air quality standards
Increase noise levels (dB) at frontage roads	Noise barriers and berms at affected receivers Soundproofing systems at schools and churches Quiet pavement at frontage roads	√	√	Meet the noise abatement criteria
Decrease number of jobs accessible by transit within 35 min travel time	Traffic signal coordination to mitigate congestion on frontage roads Improvements to walk-transit linkages (e.g., sidewalks and bus stops)	√	√	Increase number of job accessible by transit within 35 min travel time
Increase vehicle volumes on local streets, including truck volumes	Ban heavy vehicles from neighborhood streets Improvements to traffic signals, traffic signs, and pavement markings Traffic calming devices such as speed bumps, street closures, restricted access, and brick paving to reduce vehicle speeds and cars' dominance, and control de behavior of the remaining drivers	√	√	Decrease traffic volumes in local streets and improve traffic safety
Decline of pedestrian safety on local streets	Improvements to sidewalks and pedestrian crossing opportunities Improvements to pedestrian signals, signs, and pavement markings	√	√	Enhance pedestrian safety

Box 11.8 Sharing with the EJ Community the Magnitude of the Mitigated Impacts (Example)

A transportation agency is considering the conversion of an existing non-toll road into a toll road by tolling the existing lanes and adding adjacent frontage roads as *free alternatives*. The analysis of the magnitude of the additional impacts revealed that EJ populations would be disproportionately burdened by this conversion. Actions to mitigate these disproportionate adverse impacts were conceptualized and designed based on the EJ community input and engineering analysis. The mitigated impacts (see Table below) will help ensure that the planned conversion will be designed, built, and operated without disproportionate disruption to the EJ community.

EJ Burden (Step 5)	Potential Mitigation Options (Step 6)	Measured Impact		Comment
		Before mitigation (Step 4)	After mitigation (Step 5 + Step 6)	
Displacement of residential properties	Fair relocation benefits to displaced residents	√	√	Enhance housing relocation site
	New housing units			
	Improvements to public areas at the relocation site (e.g., sidewalks, bikeways, parks, and playgrounds)			
	Improvements to public services at the relocation site (e.g., health care centers, schools, and community centers)			
Displacement of local businesses	Fair relocation benefits to displaced businesses	√	√	Enhance business relocation site
	Maintain/enhance access to displaced businesses at the relocation site (e.g., improvements to traffic signals, traffic signs, pavement markings, sidewalks, and lighting)			
Financial burden for low-income households	Variable toll rate based on household income	√	√	Enhance transportation alternatives for low-income travelers
	Toll refunds/exemptions for low-income households			
	Free toll to high-occupancy vehicles such as buses and carpools			

Chapter 12 Conclusions and Recommendations

Environmental Justice (EJ) legislation and regulation are designed to protect the health and welfare of specific populations. Although the importance of environmentally just transportation projects is widely recognized, appropriate documents to guide transportation decision makers in assessing EJ concerns particularly pertinent to tolled facilities are largely unavailable. It is foreseeable that toll road projects could hold additional benefits as well as burdens for EJ communities compared to non-toll road projects. From the literature it is clear that toll roads can have EJ impacts on the physical, mobility, safety, social and economic environments that differ from non-toll roads. To date, however, very little guidance exists on how to assess the additional benefits and burdens imposed by toll roads compared to non-toll roads, and how to mitigate any negative impacts. Many professionals believe EJ analysis can be achieved through public involvement, but a more comprehensive EJ assessment requires both a qualitative and quantitative analysis. Furthermore, previous research studies have employed statistical analysis to estimate the location of minority and low-income populations in relation to toxic chemical releases, rather than to transportation facilities. These studies have tended to emphasize existing circumstances (e.g., whether minority populations are suffering injustice from a current site) rather than seeking to predict EJ concerns that might occur if a transportation facility were to be constructed (e.g., whether low-income drivers would be disproportionately impacted by the building of a proposed toll road). The objective of this research was to develop a robust approach for the effective identification, evaluation, and mitigation of disproportionately high impacts imposed on minority and low-income communities (EJ communities) by toll roads relative to non-toll roads given four specific scenarios. The scenarios were conceptualized considering the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission.

The principles underlying the recommended EJ evaluation methodology (EJEM) are (a) the qualitative and quantitative approach for assessing "disproportionately high and adverse effects" imposed by a toll road on EJ communities relative to a non-toll road project and (b) the "meaningful" involvement of minority and low-income populations in the decision-making process surrounding proposed toll road projects. The recommended methodology has two equally important components: an analysis/quantitative and an effective EJ participation component. The analysis component requires the analyst to:

- identify the demographic profile and the spatial distribution of population groups within the impacted area by using an appropriate geographic scale,
- identify the spatial concentrations of EJ communities in the impacted area,
- determine the additional impacts of concern associated with the toll road relative to the non-toll road,
- calculate the magnitude of the additional impacts,
- determine whether zones with higher concentrations of EJ populations are disproportionately impacted by the toll road, and finally
- identify and formulate effective mitigation options if it is found that the impacts on zones with higher concentrations of EJ populations are appreciable more severe than the impacts on zones with lower or no concentrations of EJ populations.

The second component, EJ participation, aims to ensure that EJ communities are given the opportunity for meaningful participation. A key component of the EJEM is the inclusion of minority and low-income populations in the planning process, in providing input in research and data collection needs, in project design, in determining the benefits and burdens of proposed facilities, and in identifying mitigation measures. EJ outreach efforts are thus foreseen during the various steps of the analysis to ensure that (1) all EJ communities (neighborhoods) are identified, (2) all the adverse impacts are identified and prioritized, (3) the measured impacts are shared with the impacted communities, and (4) effective mitigation options are designed in consultation with the impacted EJ community. Public outreach techniques are important in facilitating the dialogue between the transportation agency and the impacted community while also exposing core community concerns. In this regard, the transportation agency should first and foremost gain a true understanding of the impacted EJ communities. In addition to gathering basic demographic information describing the affected population, the transportation agency should improve its knowledge regarding the barriers that prevent meaningful EJ public participation.

This research highlights the content and geographic scales of census data products relevant to EJ analysis and provides guidance regarding the variables included in these products that may be used to identify (a) the spatial distribution of EJ populations and (b) potential barriers that might prevent EJ community meaningful participation. It is, however, evident that income data is not available at the census block level. This research estimates an income model, called the *block-low-income model*, to address this limitation in conducting EJ assessments of toll road projects that require a higher degree of demographic resolution.

Using available U.S. Census Data, this study builds a *block-low-income model* to estimate low-income populations at the block level. The approach presented in this research demonstrates the importance of assessing the spatial context of observations in an effort to estimate an improved model that accounts for spatial autocorrelation. In general, the classic Ordinary Least Square (OLS) estimates are sensitive to the model specification and the presence of spatially correlated estimation errors. If observations are not independent, it may result in some coefficients considered as significant when in fact they are not. If there is spatial autocorrelation in the residuals, the model may overestimate or underestimate the observed values. Spatial econometric models extend regression analysis to account for the fact that data used in model estimation often relates to specific geographic areas and therefore may exhibit a certain spatial pattern. The spatial models assist in revealing the explanatory variables that are statistically significant after accounting for spatial autocorrelation. If OLS residuals are correlated, it is better to find the missing variables that explain the spatial pattern in the residuals. Local knowledge can be key in finding the missing variables. At the very least, clusters and spatial outliers should be viewed as places of interest warranting further study.

This study reveals that the conventional approach of using threshold values, which classifies communities into target and non-target populations, is sensitive to both the geographic scale and the community of comparison (COC) used. *The sensitivity analysis of different geographic scales* showed that the spatial distribution of target and non-target minority/low-income populations within the study area changed when the scale of geographic analysis (i.e., tracts, block groups, blocks, and Traffic Analysis Zones [TAZs]) changed. In this regard, the analysis makes evident that the course scale of TAZs used in travel demand modeling might overlook smaller minority/low-income population groups. A more complete spatial distribution of the EJ communities was obtained at the block level and it is therefore considered more appropriate to assess EJ concerns of toll-road projects with differential impacts on the impacted population. A very detailed scale of demographic analysis (i.e., block level) is thus recommended for toll road projects if (a) the impacts are not uniformly distributed over the impacted area, (b) there is a possibility that smaller minority and low-income communities might be overlooked at more aggregate levels of geographic analysis, and (c) the proposed toll project is perceived to be highly controversial. Finally, a number of low-income communities at the project level could also be potentially overlooked by using the state as the COC and thus the state poverty rate as the threshold value to identify target populations.

The results from the *sensitivity analysis of different geographic scales* revealed the need for an innovative approach to identify the spatial distribution of EJ communities impacted by toll road projects. Since it has been argued that effective EJ analysis should consider all minority/low-income population groups, regardless of their size, this research presents an innovative approach to identify the concentration of EJ individuals in the affected project areas.

To identify concentrations of EJ populations, this research used U.S. Census Data, spatial autocorrelation measures at the census block level, and Geographic Information Systems (GIS) modeling in vector and raster data structures to both categorize minority and low-income populations by concentration levels and define zones as a function of EJ concentration levels and established connectivity criteria. Zones with low, medium, high, and extremely high concentrations of EJ populations can thus be defined within the impacted area. Each zone, instead of corresponding to a certain geopolitical unit, which do not necessarily recognizes the spatial patterns of EJ communities, is homogenous in terms of concentration levels of minority populations and low-income populations. This approach therefore overcomes some of the limitations of the threshold analysis that divides the community into two groups (i.e., target EJ population and non-target EJ population) and whose results depend on the community of comparison (COC) chosen and the geographic scale of analysis used. Also, the proposed methodology allows for the identification of small zones containing EJ populations, thereby fulfilling the federal requirement that all minority/low-income populations be considered in EJ analysis, irrespective of the size of the community.

The concentrations of EJ populations within the impacted area can be used for effective EJ analysis. Specifically, the results of the proposed approach can be used to assess who benefits and who is burdened by the potential ecological, mobility, safety, social, and economic impacts associated with the toll road condition relative to the non-toll road condition by overlaying the EJ concentration zones with the anticipated impacts. Although no clear federal guidance exists on what is a disproportionate or adverse impact, obviously if zones with high concentrations of EJ communities incur most of or significantly more of the burdens compared to zones with no or low concentrations of EJ communities there is cause for concern. Finally, the outcome map showing the spatial concentration of EJ communities can be used by state Department of Transportations to focus their community outreach efforts. Specifically, this map can help (a) to identify strategic points within the affected area for liaising with the community, (b) to obtain a sense of the scale of the effort required for validating the spatial concentration of EJ communities within the affected area, and (c) to communicate the adverse impacts and the proposed mitigation options to the affected EJ communities.

To determine the potential additional impacts (i.e., benefits and burdens) imposed by toll roads on EJ communities given the four toll road scenarios compared to non-toll roads, four key questions and examples of sub-questions were explored based on an in-depth literature review of (1) the potential ecological, mobility, safety, social, and economic impacts of highway investments, including priced facilities, and (2) the socio-demographic characteristics of the users of priced facilities. The outcome was a detailed *Toll Road Impact Matrix* that may be used by the transportation agency as a reference when identifying the additional benefits and burdens associated with toll roads as compared to non-toll roads.

This research presents a quantitative approach for measuring and comparing the magnitude of the additional impacts imposed by a toll road on EJ communities relative to a non-toll road project given four specific scenarios. The recommended approach includes the required statistical tests and power analysis to assess whether EJ communities are disproportionately impacted and interpret the non-significant findings. *EJ indexes* are provided to assess impacts on accessibility, air and noise quality, residential and commercial property values, and pedestrian and bicycle safety as conceptualized in the *Toll Road Impact Matrix*. The recommended approach further describes and evaluates the analysis tools that can be used to calculate the *EJ indexes* in terms of data requirements, expertise required, potential data sources, limitations, robustness, and cost. Once the additional impacts are quantified, the results can be overlaid with the EJ concentration zones to compare the impacts among zones with different concentration levels of EJ populations and determine whether EJ populations are disproportionately impacted by the toll road condition relative to the non-toll road condition.

Mitigation options are crucial in offsetting the adverse impacts a toll road project may have on EJ communities. Hypothetical mitigation packages to reduce or eliminate the additional ecological, mobility, safety, social, and economic burdens a toll road project may impose on minority and low-income populations given the study scenarios include (a) toll credits/toll exemptions/cash rebates for low-income travelers, (b) free toll lanes for transit and carpoolers, (c) new or expanded transit, pedestrian, and bicycle infrastructure and services that benefit EJ populations, (d) improvements to the connectivity and safety of existing non-toll roads especially on corridors priced or affected by pricing, (e) land use and development measures that encourage denser and more pedestrian-friendly neighborhoods, shopping areas and community facilities (e.g., hospitals, libraries) near transit facilities, (f) travel demand management strategies aims to improve air quality and protect human health, (g) relocation/renovation of affected housing units, public spaces, and sacred sites to ensure/protect EJ community cohesion, (h) enhancement to local businesses access, (i) fair share of contracts generated by the project earmarked for local businesses, and (j) noise barriers to mitigate traffic noise pollution on neighborhoods adjacent to the toll plaza. These measures can be used by the transportation agency as guidance since applicable mitigation options should be examined on a project-by-project basis.

In Texas, road pricing would increase equity, reduce demand for road expansion, and enhance environmental quality if toll revenues are used to finance primary EJ population travel choices, like paying for better public transit and bike-transit linkages, and the mitigation and remediation of adverse impacts to compensate those affected population groups. The Texas Administrative Code, however, restricts the use of Regional Mobility Authority's (RMA's) surplus revenue to (1) reducing tolls, (2) depositing it in the Texas Mobility Fund, or (3) constructing a transportation project, tolled or non-tolled, in a county of the RMA. There does not seem to be any mechanism for funding either transit operations, improvements to existing non-toll roads or offering cash rebates. In December 2005, the Texas Transportation Commission supported the use of excess toll revenues to finance transit systems that meet state's transportation needs. Texas statute, however, presents a number of institutional challenges that have to be fully overcome before the RMA's surplus revenue can be used to upgrade current transit services (e.g., increase frequency service), provide new transit services (e.g., new transit routes), improve existing non-toll roads, or provide monetary reimbursement to individuals.

The cost of mitigation actions to address EJ concerns might be included as part of the toll road project implementation cost. Because toll road projects must produce sufficient revenue to pay back the bond holders with interest, any action that might affect a toll road's ability to repay its debt requires special scrutiny. Many of the proposed mitigation options for toll roads could add significant cost and uncertainty to a project. As the same time, the state is committed to fulfill the requirements for EJ analysis of toll road projects. How EJ concerns can be mitigated without creating risk for the bondholders is a question that might be the subject of a future research.

This research presents a critical review of two of 10 cases identified by the Federal Highway Administration (FHW) that exemplify effective practices in promoting EJ principles. The two cases show that a more active and engage public can improve the Environmental Impact Assessment (EIA) process and contribute to improved environmental quality. Specifically, a project planned and developed in consultation with the affected population groups will improve the outcomes, which can promote community goodwill and satisfaction. Also, dialogue is a critical component of the process to ensure the inclusion of the different perspectives advocated by the stakeholder groups. Although the two described cases concern non-toll road projects, some of the measures, actions, and strategies can be adopted for inclusion in toll-road projects, because they are equally applicable to the effective identification, evaluation, and mitigation of disproportionately high or adverse impacts on minority and low income communities Specifically, the cases illustrate (a) effective measures to ensure community cohesion, (b) strategies for effective public participation by EJ communities, as required by NEPA, the U.S. DOT, and the FHWA, to ensure that affected EJ communities have an equal influence in the decision-making process of transportation projects, and (c) effective actions to mitigate or offset the identified impacts on EJ communities.

The insights gained from the two cases identified by the FHWA that exemplify effective practices in promoting Environmental Justice (EJ) principles, the major findings from the *Telephone* and *Door-to-Door Survey*s conducted between January and April of 2006 in the potentially impacted areas of the toll road projects planned for Central Texas are presented, and the role of Geographic Information Systems (GIS) and spatial analysis in strengthening EJ public participation provided the basis to define (a) the general approach to ensure "meaningful" participation at each step of the EJEM and (b) the specific goals of the EJ outreach effort during each stage of the EJEM.

One of the core principles of Environmental Justice (EJ) analysis is the "meaningful" involvement of potentially impacted minority and low-income communities in the decision-making process surrounding the proposed investment. In general, transportation agencies recognize the need for and the clear benefits of EJ community participation, but the tasks are often times more challenging than first anticipated. The "meaningful" involvement of EJ communities requires a new perspective and emphasis, partly because conditions needs to be created that encourage the participation of people who may not have technical backgrounds, do not speak English, do not have previous knowledge of toll road issues, or distrust of government agencies. A distinct approach is thus needed to ensure the meaningful participation of minority and low-income communities in the decision-making process surrounding proposed toll road projects. The general approach to ensure meaningful participation at each step of the EJ Evaluation Methodology (EJEM) can be outlined as follows:

- Understanding the EJ community.
- Involving the EJ community in designing the public participation effort.

- Defining the goals of the EJ outreach/participation effort.
- Identifying and selecting the most appropriate participation technique(s).
- Planning, implementing, and evaluating the selected participation technique(s).

Understanding the impacted EJ communities is essential to ensure that selected public participation techniques fit into lives and culture of the community and, with proper management, get the most useful results. The EJ outreach/participation effort will be much more meaningful if principals of collaboration and consensus building are in place. By involving EJ participants in the design of the public participation effort, they gain a sense of ownership of the effort and therefore, they will be committed to success. Consensus-based techniques will also aim EJ participants to become better prepared to understand toll road technical issues and argue their concerns.

Defining the goals for the public participation efforts is imperative since EJ individuals should understand the decision-making process and the critical decision points where their input can make a difference. The EJ community should be informed and involved in the process. The goals and what can be gained will vary depending on the community and the particular stage in the EJEM. This is an important step because the analyst should be clear about the information provided to the community and the decisions they can impact to ensure a trusting relationship.

Methods for enhancing public participation have advanced to a point where a substantial body of knowledge is found in the literature. The author has carefully reviewed various techniques to determine their relevance for involving and informing EJ communities in the decision-making process. When selecting a public participation technique(s), the analyst has to consider everything learned about the community and select a technique(s) that will (a) overcome most of the barriers to participation of the specific EJ community and (b) ensure mutual agreements.

EJ outreach/participation effort requires careful planning, organization and preparation. Although each of the public participation techniques listed in this research will have specific management requirements, there are several general concepts to keep in mind. First, everything about the technique and the subsequent participation event needs to be well thought out and pre-planned. Any disorganization can lead to wasted time and effort on the day of the event. Second, the location must be well prepared. Handout materials must be ready and translated into the languages spoken in the EJ community if English is not the only language spoken. Third, staff must be well trained and prepared in terms of what they have to say and ask. Facilitators and mediators play an important role in enhancing participants' chances of reaching agreement. Fourth, time management is essential, and allotting time for different components of the event will be helpful in making the best use of the little interaction time the agency staff typically will have with those participating. Finally, consensus building techniques should be applied when seeking unanimous agreement.

The transportation agency should evaluate the effectiveness of its public outreach activities by showing EJ participants what was gained from past public participation efforts and how it affected the project outcome. This is especially important when reaching out to EJ communities, as one of the key issues is to build trust between the agency and the community.

This research presents the specific goals of the EJ outreach effort during each stage of the EJEM to ensure meaningful representation and participation of minority and low-income populations in the decision-making process of the planned toll road project. EJ outreach efforts are thus foreseen in various stages of the EJEM. First, EJ communities should be invited to participate in the decision-making process of toll road projects as early as possible to (a) identify all potentially impacted neighborhoods, including their history and values, (b) validate the spatial concentrations of EJ populations within the impacted area, (c) identify potential "avenues" to distribute information to potentially impacted EJ communities, (d) obtain input from those who can speak on behalf of the entire EJ community, (e) identify the most appropriate participation techniques for informing and involving the impacted EJ communities, (f) identify the EJ community barriers for managing and implementing the selected participation techniques, and (g) identify strategic locations for interacting with EJ communities. Next, EJ communities and their representatives should be educated about the proposed toll project and gain an understanding of the potential impacts to ensure an informed and meaningful discussion and prioritization of the impacts of concern surrounding toll roads relative to non-toll roads. Once the communities understand the technical issues and can articulate their views and concerns, meaningful and informed participation can be accomplished. At this stage, EJ people should be in a position to articulate how they think the proposed toll road would impact their activity space (i.e., the places where they work, shop, and partake in other activities) and communities. Finally, EJ communities should be (a) informed about the magnitude of the additional impacts (benefits and burdens) associated with the proposed toll road project compared to the non-toll road and (b) involved in the conceptualization and design of acceptable options to avoid, minimize, or mitigate any disproportionate impact on the community. This research lists a number of performance measures that can be used by the transportation agency to inform the impacted community of the benefits and burdens of the toll road condition relative to the non-toll road condition. The list includes the simplicity and clarity of the performance measures in terms of communicating and sharing them with the community. Once the EJ communities have gained an understanding of how they will be impacted by the toll road, appropriate mitigation options can be designed. EJ communities should actively participate in problem solving to mitigate or remediate the adverse impacts imposed on their communities. Ultimately, these mitigation options should help ensure that the toll road project is designed, built, and operated without disproportionately burdening the EJ community. In this regard, the EJ input received during this step of the EJEM should be used by the transportation agency to design an *EJ Mitigation and Enhancement Plan* that represents both community input and engineering analysis.

The *EJ Mitigation and Enhancement Plan* should not be envisioned as the end of the EJEM. The addition of monitoring and management step partially addresses whether the primary purposes of the EJ assessment of a toll road project is achieved or not. The inclusion of an auditing step makes it possible to address broader environmental output questions, such as the accuracy of the impacts forecast and the effectiveness of the EJ assessment, including the actions to mitigate any disproportionately impact.

Finally, the products developed in this research provide transportation planners and decision makers with a robust and defendable methodology to address EJ concerns associated with toll road projects in Texas. It will also serve as a model for other U.S. states with similar equity concerns regarding the health and welfare of protected populations in relation to transportation projects. To validate the proposed approach, it is recommended that the proposed methodology be piloted in one or two areas that are considering toll road projects.

Appendix A: Telephone Survey of Community-Based Organizations in Impacted Environmental Justice Communities

In January and February of 2006, religious groups, schools, and neighborhood associations serving environmental justice (EJ) communities potentially impacted by the proposed toll road system in Central Texas were surveyed by phone. The survey design, methodology, response rates, major findings, and concluding remarks are presented in this Appendix.

A.1 Survey Design

A.1.1 Survey Objective

The main objectives of contacting community-based organizations (i.e., religious groups, schools, and neighborhood associations) serving EJ communities potentially impacted by the proposed toll road system in Central Texas were to (a) determine the minority and low-income populations served by the organization, (b) establish the existing level of awareness about proposed toll roads, (c) establish whether they thought the proposed toll roads will impact their constituents, (d) determine the organization's willingness to participate and facilitate future EJ community outreach efforts, and (e) identify the outreach activities preferred by the EJ community (e.g., formal meetings, informal meetings, focus groups, telephone surveys, personal interviews, and questionnaires by mail).

A.1.2 Target Population and Sampling Units

The target population were the community-based associations located within the area impacted by the proposed toll roads in Central Texas. The proposed plan includes new tolls (i.e., SH 130, SH 45 North, Loop 1 North, 183A, and SH 45 Southeast) and toll lanes in the median of existing highways (i.e., US 290 East, US 183 South, and SH 71

East). Based on the Final Environmental Impact Statement for SH 130 (U.S. Department of Transportation & Texas Department of Transportation, 2001), it was assumed that a 6-mile wide buffer along the proposed toll road alignments (see Figure A.1) would cover the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the proposed toll road system.

The contact details for religious groups, schools, and neighborhood associations within the impacted area were obtained using Geographic Information Systems (GISs) and the web. This required the following steps: first, zip codes within the impacted area were identified by map overlays. Second, the web was used to compile a contact list of all churches, schools, and neighborhood associations with the identified zip codes. The list contained the organization's name, physical address, telephone and fax numbers, and contact names (if available). Using the compiled physical addresses, the organizations were mapped in GIS. In total, the target population consisted of 494 units broken down into 230 religious groups, 197 schools, and 67 neighborhood associations (see Table A.1).

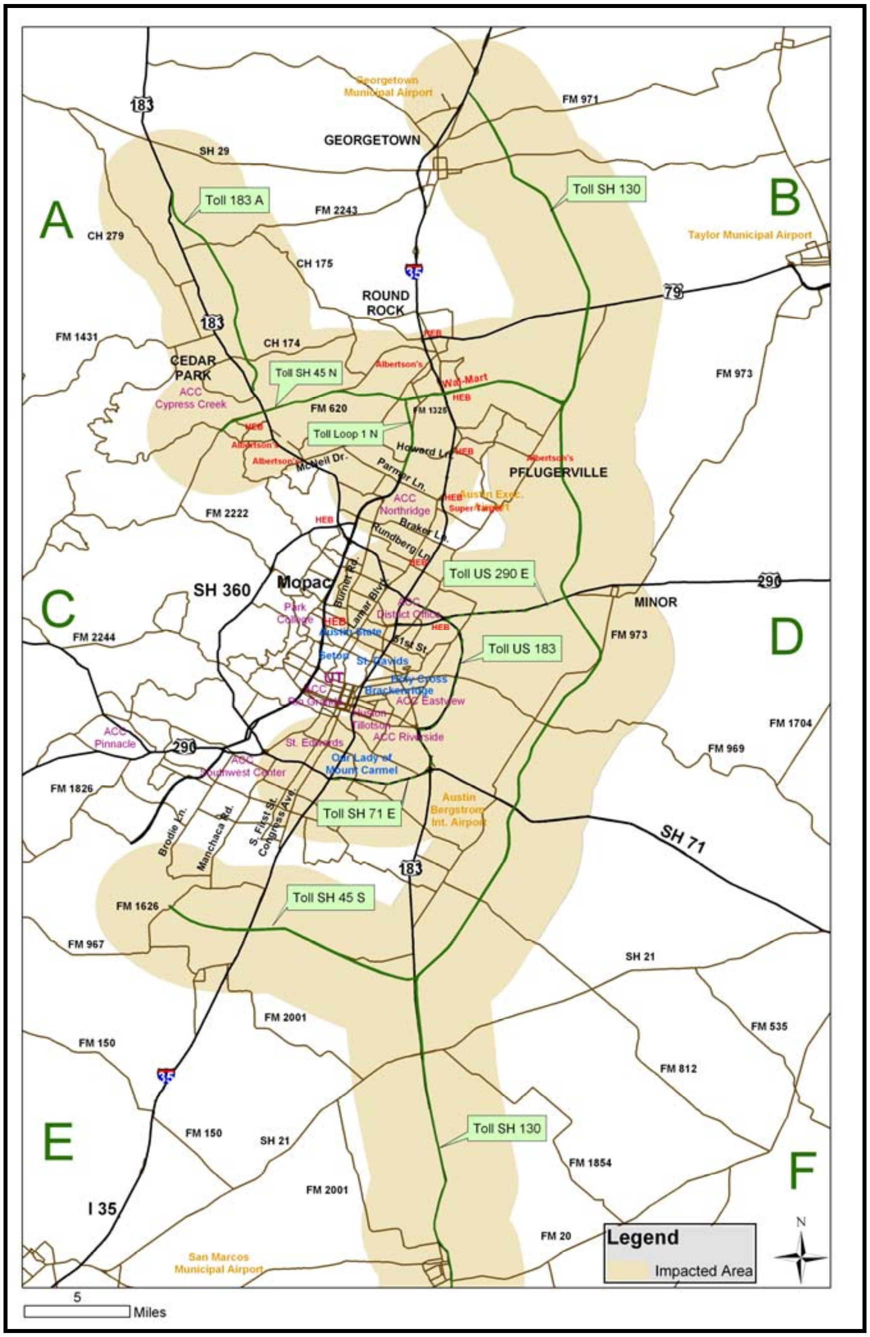


Figure A.1 Impacted Area

Table A.1. Target Population

Community-Based Organizations	Total Units	Percentage
Religious Groups	230	46 %
Schools	197	40 %
Neighborhood Associations	67	14 %
TOTAL =	494	100 %

A.1.3 Sampling Method

Stratified random sampling with proportional allocation was used as the sampling method to ensure that the sample reflected the population with respect to the stratification variable (i.e., type of community-based organization). Furthermore, proportional allocation ensured that each unit in the sample represented the same number of units in the population.

A.1.4 Survey Methodology

In-person telephone interviews were conducted to minimize respondent burden and increase participation. Telephone survey methodology generally ensures higher response rates because the respondent can perform the task of providing the information orally without further burden (Lawson, 2002). Telephone surveys also provide opportunities for clarifying the purpose of the survey, the use of the collected information, and the meaning of the questions. Although telephone surveys typically require callbacks and specific calling hours, the method provides higher response rates than other survey techniques such as mail questionnaires (Dillman, 1978).

A.1.5 Survey Forms

Figures A.2, A.3, and A.4 present the three questionnaires used to survey the religious groups, schools, and neighborhood associations, respectively. Although the questionnaires were customized for each type of organization, the questions were essentially the same.

Survey Administered to Religious Groups

Interviewer: Good morning/afternoon. My name is ___________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since your congregation can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. Where within the Austin metropolitan area does a majority of your congregation reside? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic location of the religious group that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the congregation boundaries.

2. How many people are in your congregation? _______

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e., American Indian and Alaska Native). Based on this, what percentage in your congregation would you consider minorities? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of your congregation would you consider poor? _________ %

5. How aware do you think your congregation is regarding the proposed toll roads in the City of Austin and surrounding area?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that your congregation will be impacted by the toll roads planned for Central Texas?
   ___ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on the members of your congregation?
   a. If yes, what are the best means for informing your community regarding proposed toll roads? ____

Interviewer : Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact ___________ by email at ____ or by phone at ______________. Once again, thank you and have a great day.

Figure A.2 Questionnaire Used for Religious Groups

Survey Administered to Schools

Interviewer: Good morning/afternoon. My name is ________________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since families within your school can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. Where within the Austin metropolitan area does a majority of the families served by your school reside? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic boundaries of the school district that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the school boundaries.

2. How many students are in your school district? __________

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e. American Indian, and Alaska Native). Based on this, what percentage of the families serviced by your school district would you estimate is considered minority? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of the families served by your school district would you consider poor? _________ %

5. How aware do you think families in the school district limits are regarding the proposed toll roads in the City of Austin and surrounding area?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that the families served by your school district will be impacted by the toll roads planned for the City of Austin and surrounding? ___ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on the families served by your school district?
   a. If yes, what are the best means for informing your community regarding proposed toll roads? ____

Interviewer: Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact _____________ by email at ______________________________ or by phone at ________________. Once again, thank you and have a great day.

Figure A.3 Questionnaire Used for Schools

Survey Administered to Neighborhood Associations

Interviewer: Good morning/afternoon. My name is ________________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since the members of your neighborhood association can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. What are the geographic boundaries of your neighborhood association? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic boundaries of the neighborhood association that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the neighborhood boundaries.

2. What is the approximate total population within your neighborhood association limits?

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e., American Indian and Alaska Native). Based on this, what percentage of the population within your neighborhood association limits would you consider minority? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of the population within your neighborhood association limits would you consider poor? ________ %

5. How aware do you think the members of your neighborhood association are regarding the proposed toll roads in the City of Austin and surrounding area?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that the members of your neighborhood association will be impacted by the toll roads planned in the city of Austin and surroundings? ____ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on your neighborhood?
   a. If yes, what are the best means for informing your community regarding proposed toll roads?
   ____

Interviewer: Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact _________________ by email at ______________________________________ or by phone at _________________. Once again, thank you and have a great day.

Figure A.4 Questionnaire Used for Neighborhood Associations

A.2 PILOT SURVEY

A pilot survey was administered in early January 2006 to gather information and to formulate the design and administration of the main survey. The pilot survey allowed the testing of the following aspects of survey approach:

- Data collection method. How easy or difficult it is to collect the required data using the selected survey method (i.e., telephone interviews).
- Question wording. To determine not only whether respondents understand the questions as the survey designer does, but also that every respondent understands each question the same.
- Nonresponse rate. The number of refusals or nonreachable contacts from the pilot survey offered a means to estimate the main survey response rate (given the same sampling method and survey approach for both the pilot survey and the main survey). Causes of nonresponse were noted to adjust the survey administration process (e.g., the best times to phone the school officials were noted). The pilot nonresponse rate was also used to determine the total number of units to be sampled for the main survey.

A.2.1 Sample Size

A 3% simple random sample (SRS) with proportional allocation was taken within each stratum (see Table G.2). This means that each religious group in the sample represents 33 religious groups in the population; each school in the sample represents 33schools in the population; and each neighborhood association in the sample represents33 neighborhood associations in the population.

Table A.2. Pilot Survey: Sample Size

Community-Based Organizations (Stratum)	Total Units	Sampled Units (3% of total units)
Religious Groups	230	7
Schools	197	6
Neighborhood Associations	67	2
TOTAL =	494	15

A.2.2 Effective Response Rate

Table A.3 provides the detailed response information for the pilot survey.

Table A.3. Pilot Survey: Response Information

Community-Based Organizations	Sampled Units (3% of Total Units)	Refusal Units	Non-reachable Units	Completed Survey Units
Religious Groups	7	2 (29%)	4 (57%)	1 (14%)
Schools	6	0 (0%)	4 (67%)	2 (33%)
Neighborhood Associations	3	0 (0%)	1 (33%)	2 (67%)
TOTAL =	15	2 (14%)	8 (53%)	5 (33%)

Overall, the pilot survey achieved a 33% effective response rate. On average, the telephone survey was thus considered an appropriate data collection method to reach religious groups, school officials, and neighborhood associations.

A.2.3 Lessons Learned

Religious Groups

The religious groups were surprisingly unresponsive (see Table G.3). Of the seven churches contacted during the pilot survey, two refused to complete the survey, two telephone numbers were disconnected, two never answered and the interviewer went straight to the voicemail, and the remaining religious group completed the survey. This respondent found question 1 to be extremely difficult to answer. Congregation members could come from any part of the city and were not constrained by geographic boundaries.

The respondent could only remark that 25% of the congregation came from Northwest Austin while the rest of the congregation resided throughout the city. Question 1 was subsequently reworded (see Box A.1).

Box A.1 Question 1

In the pilot survey*: What are the geographic boundaries of the area that your congregation resides in?*

In the main survey*: Where within the Austin metropolitan area does a majority of your congregation reside? (North, East, South, West, Central, Northwest, Southwest, Northeast, Southeast)*

Note: The interviewer used a map during the interview to aid in identifying the geographic boundaries of the congregation.

School Official

Two responses were obtained from the sample of six schools (see Table G.3). Two of the remaining four sampled units had telephone numbers that were forwarded to voicemails and two required repeated call backs with the result that these four units were never reached.

Because the school secretary is most likely to answer the phone, the interviewer should quickly identify himself and subsequently ask to speak to the school administrator rather than allowing the secretary to forward the call to someone who may or may not be the appropriate person to answer the questionnaire.

The two school district respondents answered question 4 (i.e., percent of poor households served by the school district) based upon the percentage of students enrolled in the free lunch program. This was the easiest way for them to identify the number of poor students enrolled in their school.

Question 7 had to be reworded because it raised some concerns (see Box A.2). The two respondents were concerned about being politically involved. They were willing to distribute information about toll roads but did not want to take a position on toll road development in Central Texas.

Box A.2 Question 7

In the pilot survey*: In the future, would you be interested in participating in community outreach activities and providing input on issues related to proposed toll roads?*

In the main survey*: In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that a proposed toll road may have on the families served by your school district?*

Finally, it was learned that the best times to call school administrators were in the morning between 9 a.m. and 12 p.m. or in the afternoon between 3:30 p.m. and 4:30 p.m. The busiest time of the day for school administrators is between 2:00 p.m. and 3:30 p.m.

Neighborhood Associations

Two of the three sampled neighborhood associations completed the survey (see Table A.3). Since it appeared that many of the neighborhood association contact numbers were home telephone numbers, the best time to call was during evening hours.

The two neighborhood association respondents identified geographic boundaries of their associations with reference to nearby roads. However, these were sometimes vague and confusing (e.g., just past the hill by Webberville Rd). Thus, to clarify the meaning of this question, it was reworded similarly to that of Box A.1.

Similar to the school official respondents, the neighborhood association respondents were unsure about the meaning of question number 7. One respondent asked if that meant taking a political position on toll roads and the other asked if it meant supporting having someone speak with the neighborhood as a group. Thus, to clarify the meaning of this question, it was reworded similarly to the wording in the text box above.

A.3 MAIN SURVEY

During the 3-week period between January 23 and February 7, the main survey was administered to a SRS of religious groups, schools, and neighborhood associations from the list of community organizations that was previously compiled.

A.3.1 Sample Size

A 20% SRS with proportional allocation was taken in each stratum (see Table A.4). This means that each religious group in the sample represents five religious groups in the population; each school in the sample represents five schools in the population; and each neighborhood association in the sample represents five neighborhood associations in the population.

Table A.4. Main Survey: Sample Size

Community-Based Organizations (Stratum)	Total Units	Sampled Units (20% of Total Units)
Religious Groups	230	46
Schools	197	39
Neighborhood Associations	67	13
TOTAL =	494	98

A.3.2 Effective Response Rate

Table A.5 provides the detailed response information for the main survey. Sampled religious groups, schools, and neighborhood associations with a wrong or disconnected telephone number were discarded and replaced by another randomly sampled unit with a valid telephone number (i.e., random sampling with replacement). Also, a unit was classified as not reachable after contact was attempted on five separate occasions without success. The main survey yielded a 51% effective response rate (higher than the response rate achieved in the pilot survey).

Table A.5. Main Survey: Response Information

Community-Based Organizations	Sampled Units (20% of Total Units)	Refusal Units	Non-reachable Units	Completed Survey Units	Response Rate
Religious Groups	46	5 (11%)	16 (35%)	25 (54%)	54 %
Schools	39	8 (20%)	14 (36%)	17 (44%)	44 %
Neighborhood Associations	13	0 (0%)	5 (38%)	8 (62%)	62 %
TOTAL =	98	13 (13%)	35 (36%)	50 (51%)	51%

A.4 MAIN SURVEY RESULTS

A.4.1 Community-Based Organizations

The descriptive statistics relating to Question 2 (i.e., number of people served by the organization) are summarized in Table A.6. Histograms showing the frequency distribution of the number of people served by the community-based organizations are presented in Figure A.5.

Table A.6. Number of People Served: Descriptive Statistics

Community-Based Organizations	Descriptive Statistics			
	Number of Respondents	Number of People Served	Average	Standard Deviation
Religious Groups	25	24,712	988	1,396
Schools	17	12,086	711	324
Neighborhood Associations	7	4,572	653	564

Table A.6 shows that on average religious groups serve the most people. Figure A.5, however, reveals that religious groups exhibit the greatest variability in terms of number of people served when compared to schools and neighborhood associations.

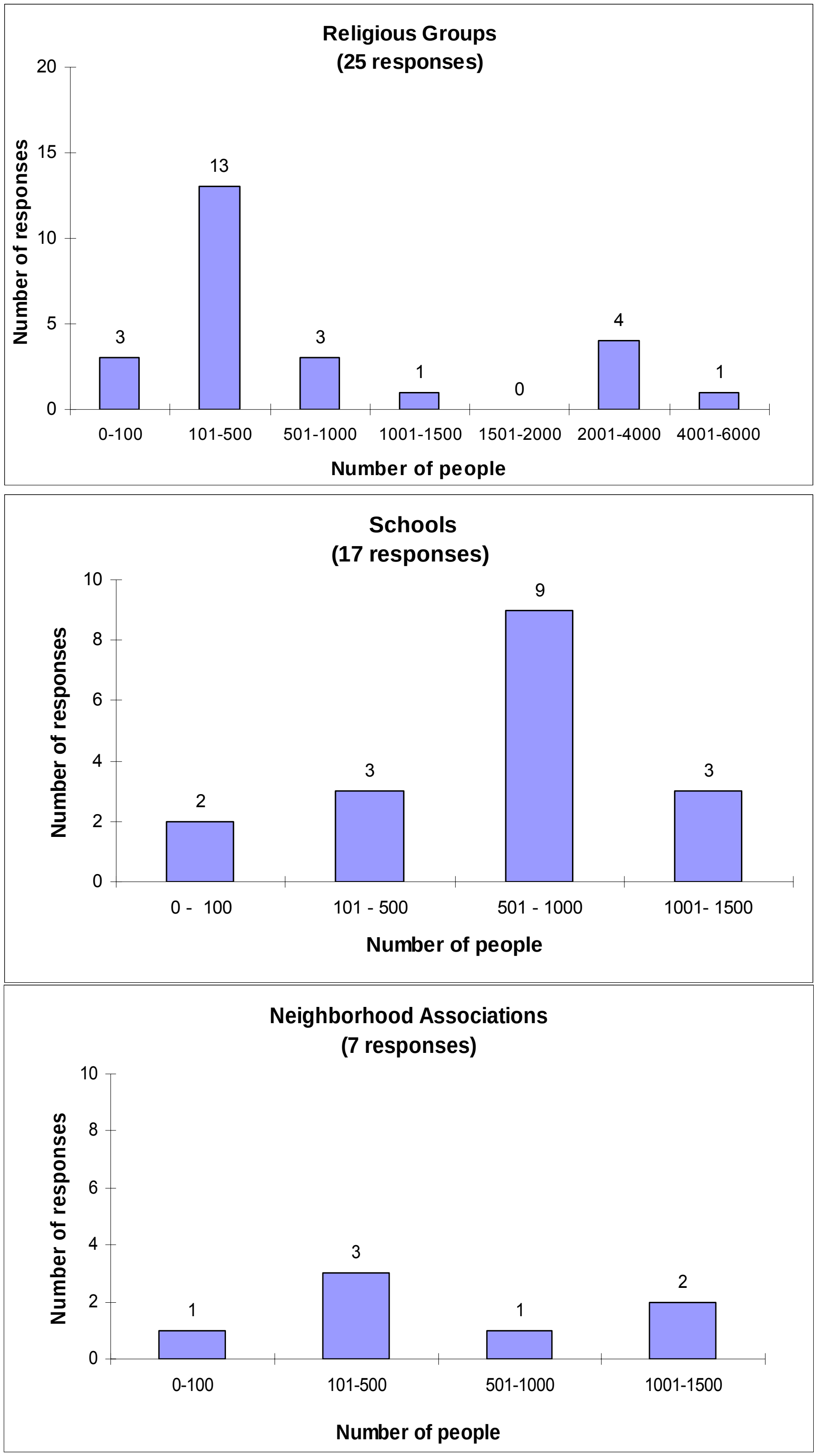


Figure A.5. Number of People Served by Community-Based Organizations

A.4.2 Percent of Minority and Low-Income Population in Community-Based Organizations

Figure A.6 provides the histograms of the percent of minority and low-income populations represented in the surveyed community-based organizations. These histograms can be used to identify those organizations that represent a large percentage of minority and low-income populations to serve as “avenues” for informing and involving EJ communities in subsequent EJ community outreach activities.

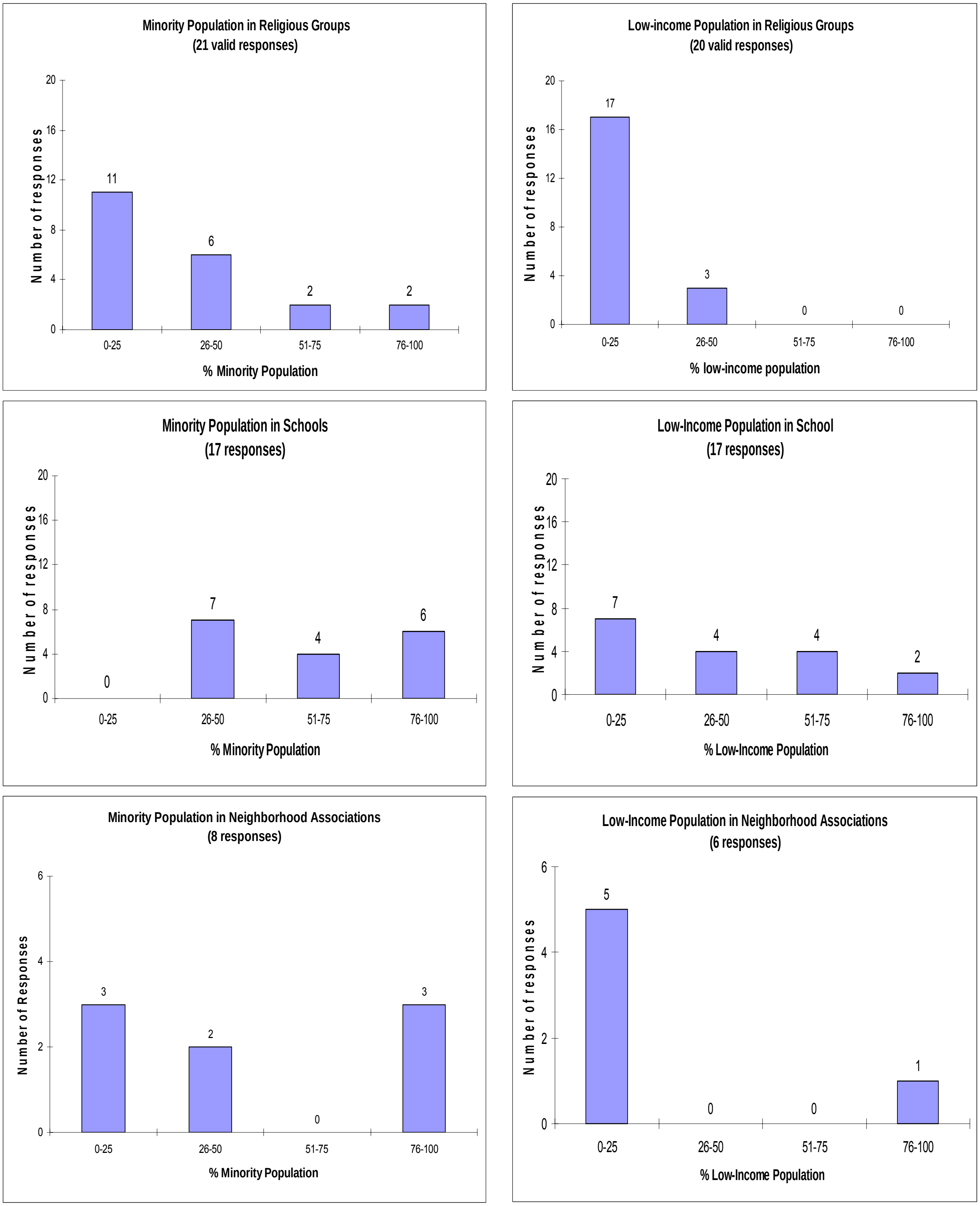
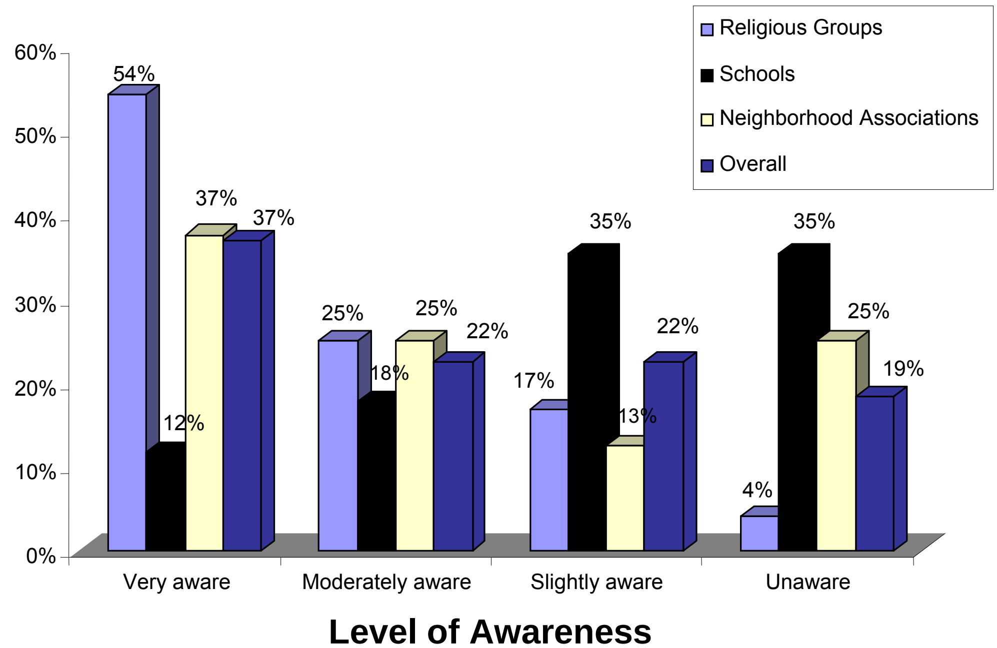


Figure A.6. Percentage of Minority and Low-Income Populations Represented in the Community-Based Organizations

A.4.3 Level of Awareness of Community-Based Organizations Regarding ProposedToll Roads

Figure A.7 illustrates the level of awareness of the members of the community-based organizations as perceived by the respondents interviewed. Based on forty-nine valid responses, most members of the religious groups (54%) and the neighborhood associations (37%) were aware of the proposed toll road system whereas schools (12%) were the least aware of the proposed toll facilities. Overall, more than one-third of the surveyed organizations were very aware regarding the planned toll road system in Central Texas.

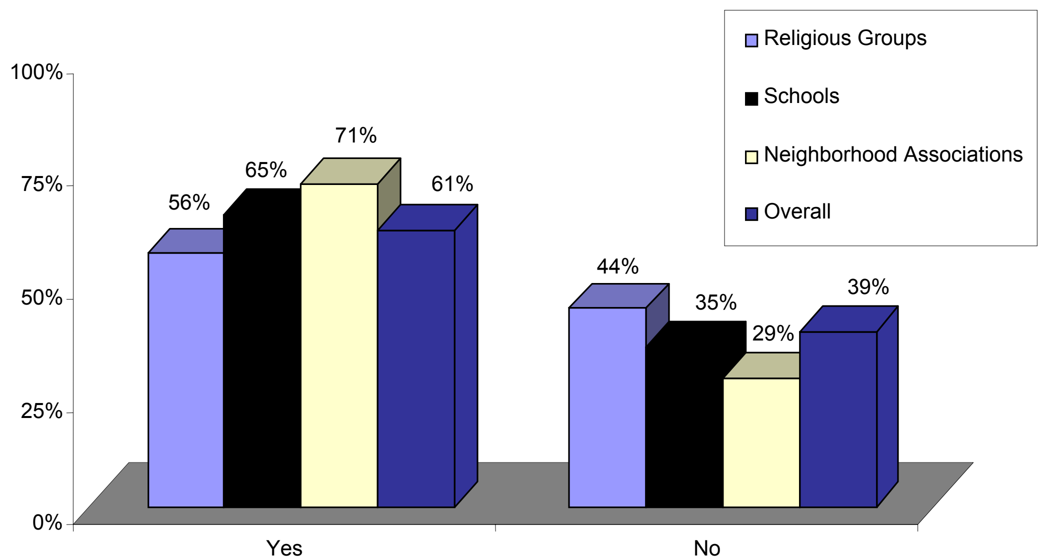


Level of awareness	Religious Groups		Schools		Neighborhood Associations		Overall	
	Responses	%	Responses	%	Responses	%	Responses	%
Very aware	13	54	2	12	3	37	18	37
Moderately aware	6	25	3	18	2	25	11	22
Slightly aware	4	17	6	35	1	13	11	22
Unaware	1	4	6	35	2	25	9	19
Total Valid Responses	24	100	17	100	8	100	49	100

Figure A.7. Level of Awareness of the Proposed Toll Roads

A.4.4 Impacts of Toll Roads

Figure A.8 illustrates whether the respondents thought the proposed toll road system in Central Texas will impact their constituents. Based on forty-nine valid responses, more than 60% of the respondents indicated that the proposed toll roads will impact their constituents.

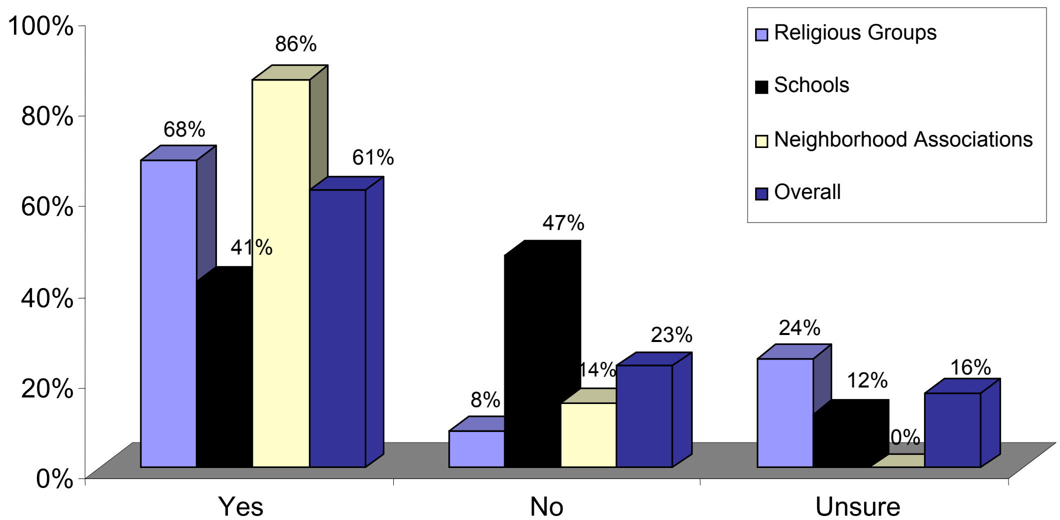


	Religious Groups		Schools		Neighborhood Associations		Overall	
	Respons es	%	Responses	%	Responses	%	Responses	%
Yes	14	56	11	65	5	71	30	61
No	11	44	6	35	2	29	19	39
Total Valid Responses	25	100	17	100	7	100	49	100

Figure A.8. Impact of Toll Roads

A.4.5 Willingness to Participate in Community Outreach Activities

Figure A.9 shows the respondents' willingness to participate in community outreach activities to be informed about the proposed toll road system in Central Texas. Based on forty-nine valid responses, the most willing to participate are the neighborhood associations (86%) followed by the religious groups (68%) and the schools (41%). Overall, 60% of those surveyed expressed their willingness to participate in community outreach activities.

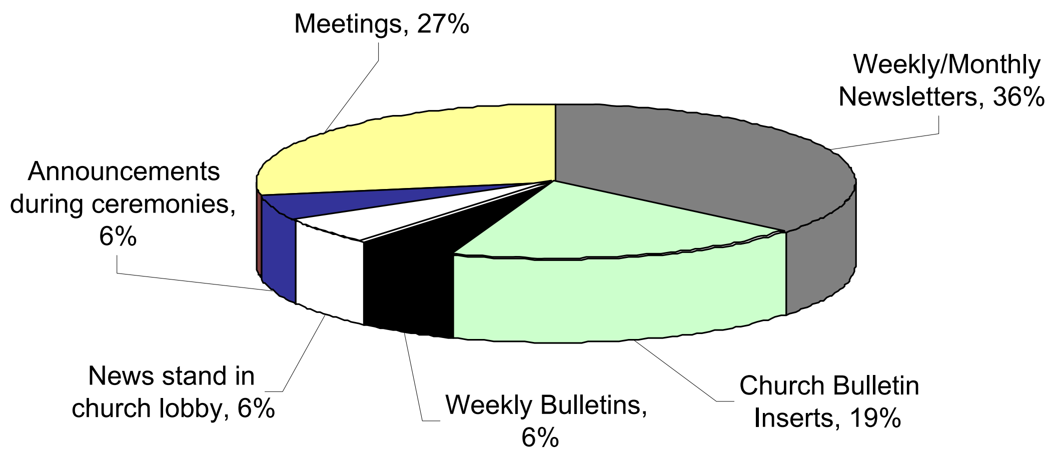


	Religious Groups		Schools		Neighborhood Associations		Overall	
	Responses	%	Responses	%	Responses	%	Responses	%
Yes	17	68	7	41	6	86	30	61
No	2	8	8	47	1	14	11	23
Unsure	6	24	2	12	1	0	8	16
Total Valid Responses	25	100	17	100	7	100	49	100

FigureA.9. Willingness to Participate in Community Outreach Activities

A.4.6 Avenues for Informing Communities about Proposed Toll Roads

Figure A.10 lists the best avenues or methods for informing communities about the proposed toll road system in Central Texas as indicated by respondents. Newsletters and meetings were indicated by the respondents to be the two preferred avenues for informing EJ communities about planned toll road facilities.



Avenues of Communication	Religious Groups	Schools	Neighborhood Association	Overall	
	Responses	Responses	Responses	Responses	%
Weekly/Monthly Newsletters	11	---	2	13	36
Church Bulletin Inserts	7	---	---	7	19
Weekly Bulletins	2	---	---	2	6
News Stand in Church Lobby	2	---	---	2	6
Announcements During Ceremonies	2	---	---	2	6
Meetings	---	7	3	10	27
			Total Valid Responses	36	100

Figure A.10. Avenues for Informing Communities about Proposed Toll Roads

A.5 CONCLUDING REMARKS

The response rate of the religious groups contacted was very high (54%). Of the thirty sampled units, twenty-five agreed to participate while only five declined to complete the survey. An important observation that has to be noted is the fact that a large number of the original sampled religious groups had inaccurate or disconnected telephone numbers. The interviewer thus had to discard sixteen churches that had automated message systems or simply did not answer the phone. A concern is that some smaller churches or churches in extremely poor neighborhoods may not have full or even part-time staff to answer the telephone. It is possible that a survey methodology other than the telephone survey needs to be adopted to contact these churches. Finally, the church respondents were very knowledgeable about their congregations and appeared willing to serve as an avenue to both inform and involve their congregations about planned toll road projects in Central Texas. Most surveyed churches publish a monthly newsletter and offered this as a mean to distribute information to their congregation.

Of the thirty-nine sampled schools, seventeen officials completed the survey and the remaining eight were unwilling to participate, producing a response rate of 44%. It has to be noted that it was extremely hard to get in touch with school officials. They are often in meetings, off-campus, or out of their offices on school grounds, thus requiring repeated call backs. In spite of the modifications to the wording of question 1 (for more details see Appendix A), school officials struggled to identify the geographic boundaries of their schools. Some of the respondents indicated that school boundaries are constantly changing while others noted that the schools do not have set boundaries. On the other hand, school officials were in a position to give a good estimate of the minority families and poor families served by the schools by using the percentage enrollments in their free and reduced lunch program. Finally, although some school officials were willing to participate in community outreach activities by hosting information gathering events, others were concerned about political implications, did not have the space for meetings, were already overburdened with meetings, were worried about the paperwork needed to approve non–school-related meetings, or were simply not interested. Those that were willing to host meetings believed weekday evenings were the best time to conduct such meetings.

Of the thirteen sampled neighborhood associations, eight agreed to complete the survey while the remaining five were unwilling to participate, which resulted in a response rate of 62%. Neighborhood association respondents often struggled to provide the boundaries and population of their neighborhoods. Some, however, could provide the number of families in the neighborhood but not the exact population. Finally, the organization of neighborhood associations varied widely. Some of them rarely meet or keep in contact online, while others meet on a monthly basis and have a website. All respondents, however, were interested in this research and willing to help where and whenever possible.

Appendix B: Environmental Justice Door-to-Door Survey

One of the core principles of EJ analysis is the meaningful involvement of potentially impacted minority and low-income populations in the decision-making process surrounding transportation projects. This appendix presents the survey design, methodology, response rates, major findings, and conclusions from a door-to-door survey that was conducted between March 15 and April 2, 2006, in zones with high concentrations of minority and low-income populations in the potentially impacted areas of the SH 130 toll road and the toll road system planned for Central Texas.

B.1 Survey Design

B.1.1 Survey Objective

The main objectives of the *Door-to-Door Survey* were to assess (a) how EJ communities foresee the impact toll roads will have on their travel (i.e., work trips, shopping trips, and trips to educational facilities and hospitals), (b) how EJ communities foresee the impact toll roads will have on their communities, (c) potential mitigation options preferred by the impacted community, and (d) potential "avenues" to educate the impacted EJ communities about proposed toll roads and to involve them in the decision-making process surrounding proposed toll roads.

B.1.2 Target Population and Sampling Units

The target population was the EJ households living in the area impacted by the proposed toll roads in Central Texas. As with the Final Environmental Impact Statement for SH 130 (U.S. Department of Transportation & Texas Department of Transportation, 2001) it was assumed that a 6-mile wide buffer along the proposed toll road alignments (see Figure B.1) covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (the potential EJ concerns) associated with the proposed toll roads.

The sampling units were the housing units in zones with high concentrations of minority and low-income populations within the impacted area (see Figure B.2). Based on the 2000 U.S. Census, there are 57,489 housing units in high EJ concentration zones, which is 17% of the total housing units in the impacted area. Table B.1 provides additional information about the minority and low-income populations within the impacted area and the zones with high concentrations of EJ populations. Given the scope of the analysis, available budget, and time frame to conduct the analysis, the target sampling unit was established at 1% of the housing units (i.e., 575 housing units) in zones with high concentrations of minority and low-income populations.

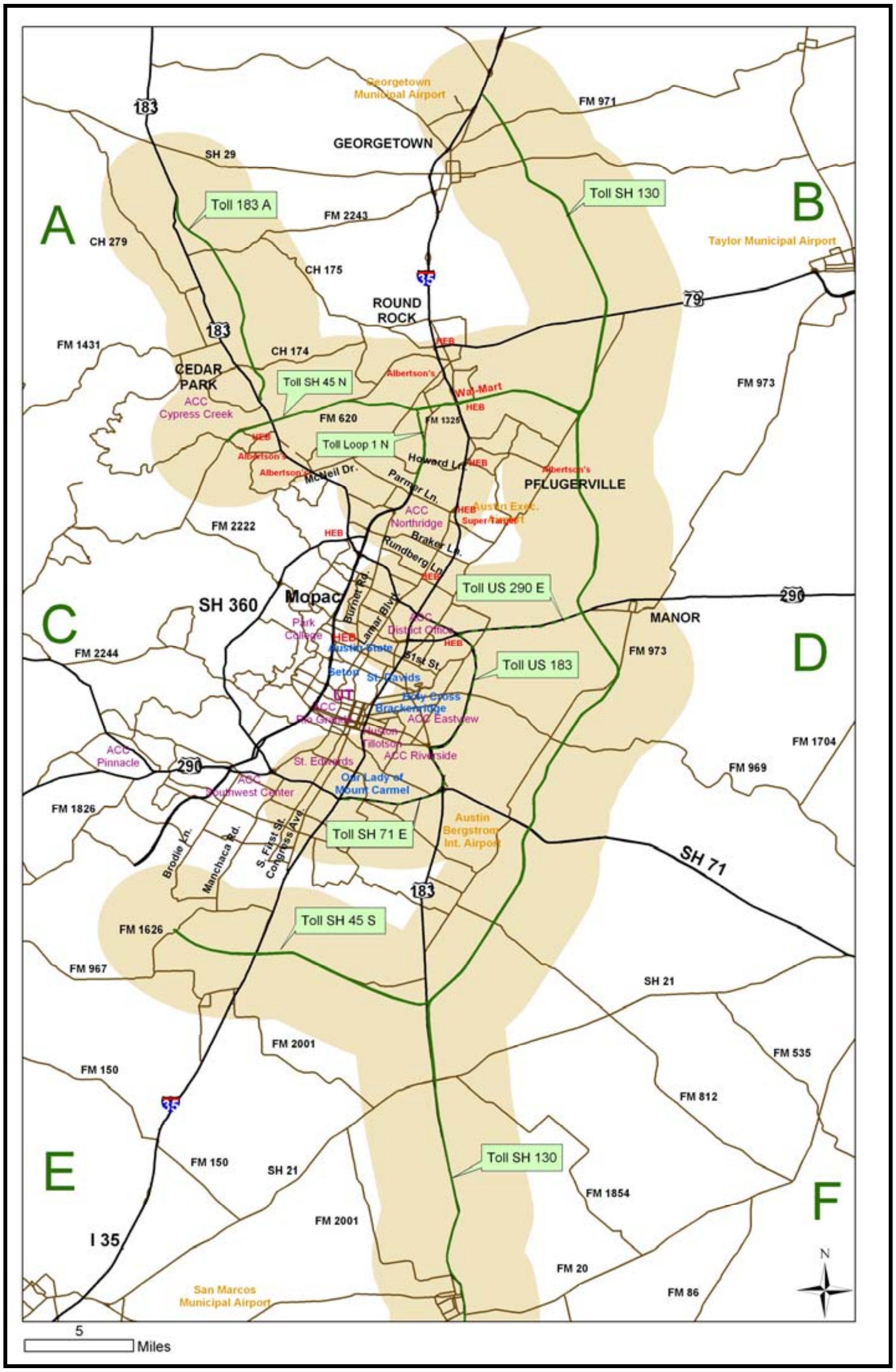


Figure B.1 Impacted Area

Table B.1 Target Population (based on the 2000 US Census)

	Total Population	Minority Population	% Minority Population
Impacted area	910,204	390,041	43%
Zones with high concentrations of minority populations	167,137	114,390	68%
	Total Population	**Low-Income Population**	**% Low-Income Population**
Impacted Area	895,959	97,339	11%
Zones with high concentrations of low-income populations	166,227	32,672	20%

B.1.3 Sampling Method

Five survey sites in zones with high concentrations of minority and low-income populations were selected (see Figure B.2). Two northern, one central, and two southern sites were identified. The housing units to be surveyed were randomly chosen from the selected survey sites.

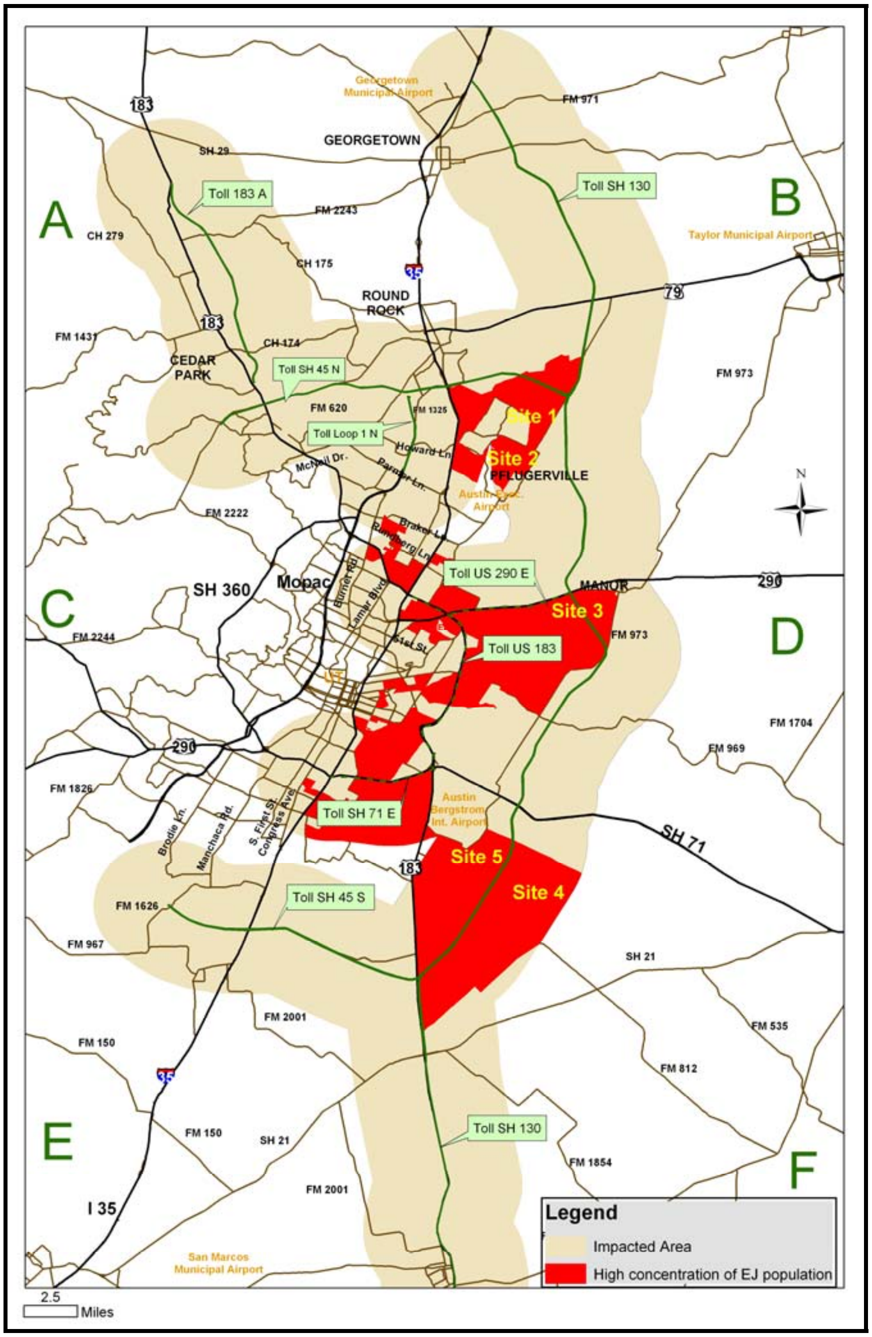


Figure B.2 Survey Sites

B.1.4 Survey Methodology

Door-to-door surveys were conducted in the five identified survey sites. This survey method, although comparatively more costly and time consuming per respondent than other survey techniques, was chosen because it overcomes many of the barriers[21] preventing EJ communities from participating in other public outreach activities, minimizes respondent burden, and maximizes the response rate. The surveys were conducted between 10:00 a.m. and 6:00 pm on weekdays and weekends between March 15 and April 2, 2006. Ten survey administrators (paired in groups of two) conducted the interviews using two types of questionnaires: one pertaining to the SH 130 toll road and the other pertaining to the planned toll road system in Central Texas.

B.1.5 Survey Forms

The two survey forms and accompanying maps used to conduct the door-to-door surveys are provided in Figures B.3 and B.4. Both survey forms were prepared in English and Spanish. Questionnaire 1 pertains to SH 130 toll road. Questionnaire 2 pertains to the system of toll roads planned for Central Texas, which includes new toll roads (i.e., SH 130, SH 45 North, Loop 1 North, 183A, and SH 45 Southeast) and toll lanes in the median of existing highways (i.e., US 290 East, US 183 South, and SH 71 East). The first segment of SH 130 (between IH-35 in Georgetown and US 183 near Creedmoor), SH 45 North, Loop 1 North, and 183A are currently under construction and will open to traffic

[21] Door-to-door surveys overcome the barriers of time, access, literacy, and language faced by EJ communities that other techniques might not. The method further provides opportunities to explain the purpose of the survey, how the information will be used, and the meaning of the questions.

at the end of this year.[22] The construction of the US 290 E is scheduled to begin in 2007. Future projects include US 183 South (Ed Bluestein Blvd), SH 71 East (Ben White Blvd.), and SH 45 Southeast.[23]

[22] Central Texas Regional Mobility Authority. Project. Available at http://www.ctrma.org/?menu_id=6. Accessed: March 3, 2006.

[23] Central Texas Regional Mobility Authority. Project. Available at http://www.ctrma.org/?menu_id=6. Accessed: March 3, 2006.

QUESTIONNAIRE 1: Toll Road SH 130 and Their Impacts

Interviewer: __________________________ Date: ________ Time: _____ Site #: ____ Map #:_____

Will Toll Road SH 130 Impact YOU?

Interviewer: Mark on the map the area where the respondent live

1. Do you **WORK**? ____ Yes ____ No
   a. If yes, Where do you **WORK**? (please mark on the map)

      ____

   b. How do you usually **GET TO WORK**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

2. Do you go to **SCHOOL**? ____ Yes ____ No
   a. If yes, Where do you go to **SCHOOL**? (please mark on the map) ____________________________
   b. How do you usually **GET TO SCHOOL**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

3. Where do you usually **SHOP** FOR **GROCERIES**? (please mark on the map)

   ____

   a. How do you usually **GET TO THIS STORE**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

4. If you need to go to the **HOSPITAL**,

   Which hospital would you go? (please mark on the map)____

   a. How would you **GET TO THIS HOSPITAL**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you would drive/take to get there?____

5. Do you think that toll road **SH 130** will **AFFECT ANY OF THE TRIPS** you listed above?

   _____Yes _____ No

   a. If yes, Which **TRIPS** will be **AFFECTED**? ___Work ___School ___Grocery shopping ___Hospital
   b. **HOW** will this toll road **AFFECT YOUR TRIPS**? _______________________________________

   ____

Figure B.3 Questionnaire 1 and Accompanying Map

QUESTIONNAIRE 1: - Toll Road SH 130 and Their Impacts

Interviewer: ________________________ Date: ________ Time: _____ Site #: ____ Map #:____

Will Toll Road SH 130 Impact YOUR COMMUNITY?

6. Do you think that toll road **SH 130** (shown in the map) will **AFFECT YOUR COMMUNITY**?

   ___ Yes ___ No

   If yes, check all that apply

   a. Will it **BENEFIT** your community? ____ Yes ____ No

   b. Will it **BURDEN** your community? ____ Yes ____ No

   i. If the respondent said benefits, **WHAT** do you see as the **BENEFITS** of this toll road?

   ____

   ____

   ii. If the respondent said burdens, **WHAT** do you see as the **BURDENS** of this toll road?

   ____

   ____

   iii. If the respondent said burdens, **WHAT** can **TxDOT** do to **REDUCE** or **ELIMINATE** these **BURDENS**?

   ____

   ____

Do You Want to be INVOLVED?

7. Can we **CONTACT YOU IN THE FUTURE** to find out what you think about toll roads?

   ____ Yes ____ No

8. If yes, What is the **BEST WAY TO REACH YOU**? ___ Come to my home ____ Send a questionnaire

   ____ Phone me ___ Interview me at the shopping mall/grocery store ___ Come to my church

   ____ Come to one of the schools in the community

   ____ Other way. How? ____

9. Is there **ANYONE** in your community that **CAN SPEAK FOR THE COMMUNITY**?

   _____Yes _____ No

10. If yes, Could you please **SHARE HIS/HER NAME** with us? ______________________________

Personal Information (depending on answer to question 7)

Name: ____Telephone: _______________

Address: ____

ADDITIONAL COMMENTS: ____

____

Figure B.3 Questionnaire 1 and Accompanying Map, continued

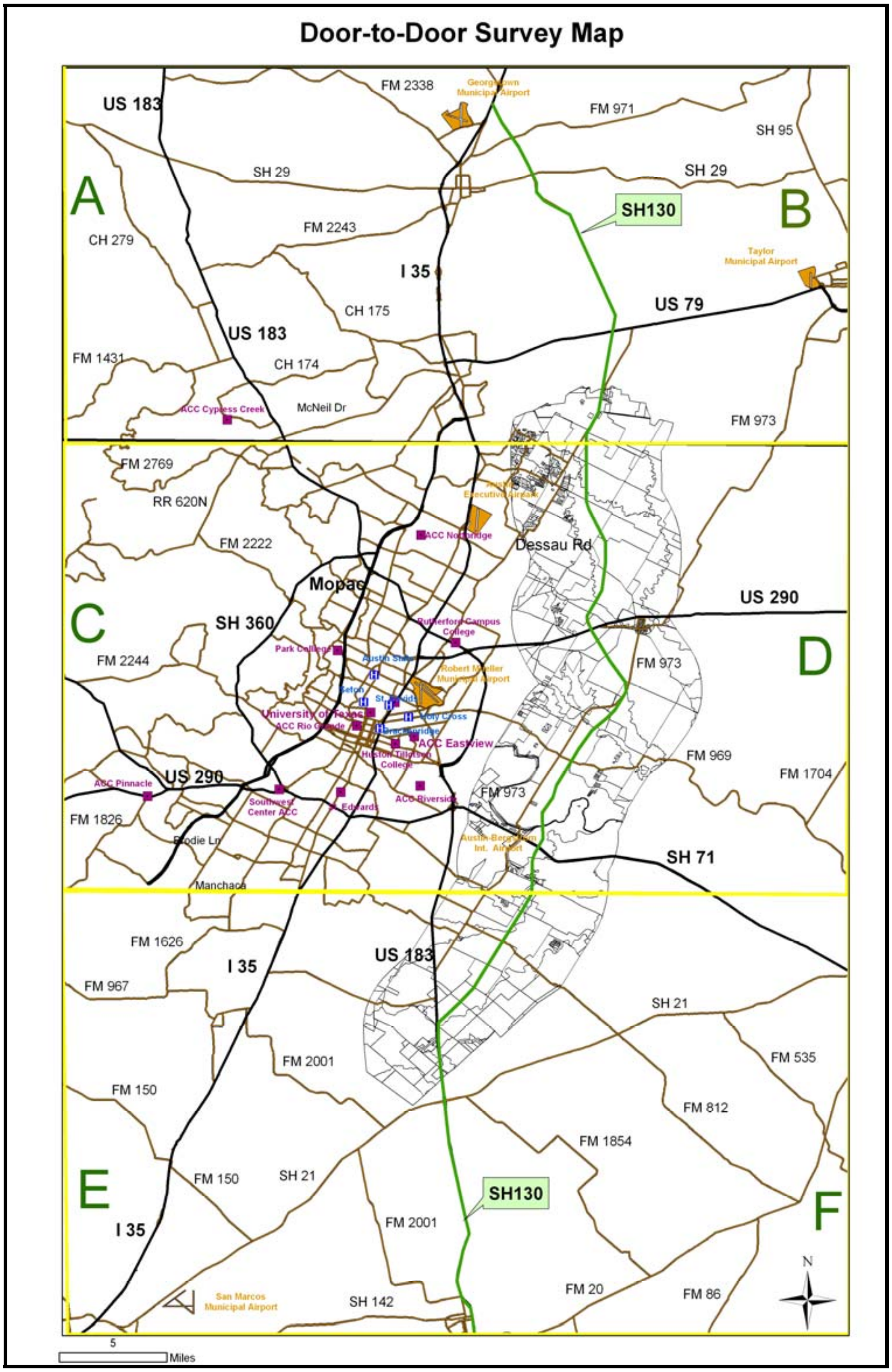


Figure B.3 Questionnaire 1 and Accompanying Map, continue*d*

QUESTIONNAIRE 2: Toll Roads in Central Texas and Their Impacts

Interviewer: ___________________________ Date: ________ Time: ______ Site #: ____ Map #: ____

Will TOLL ROADS in CENTRAL TEXAS Impact YOU?

Interviewer: Mark on the map the area where the respondent live

1. Do you **WORK**? ____ Yes ____ No
   a. If yes, Where do you **WORK**? (please mark on the map) ____________________________________
   b. How do you usually **GET TO WORK**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

2. Do you go to **SCHOOL**? ____ Yes ____ No
   a. If yes, Where do you go to **SCHOOL**? (please mark on the map) ______________________________
   b. How do you usually **GET TO SCHOOL**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

3. Where do you usually **SHOP** FOR **GROCERIES**? (please mark on the map)
   ____
   a. How do you usually **GET TO THIS STORE**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

4. If you need to go to the **HOSPITAL**, Which hospital would you go? (please mark on the map) _________
   a. How would you **GET TO THIS HOSPITAL**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you would drive/take to get there? ____

5. Do you think that **TOLL ROADS** in **CENTRAL TEXAS** (shown in the map) will **AFFECT ANY OF THE TRIPS** you listed above? ___Yes __ No
   a. If yes, Which **TRIPS** will be **AFFECTED**? ___Work ___School ___Grocery shopping ___Hospital
   b. **HOW** will these toll roads **AFFECT YOUR TRIPS**? ____
   ____
   ____

Figure B.4 Questionnaire 2 and Accompanying Map

QUESTIONNAIRE 2: Toll Roads in Central Texas and Their Impacts

Interviewer: ___________________________ Date: ________ Time: ______ Site #: ____ Map #: ____

Will TOLL ROADS in CENTRAL TEXAS Impact YOUR COMMUNITY?

6. Do you think that **TOLL ROADS** in **CENTRAL TEXAS** (shown in the map) will **AFFECT YOUR COMMUNITY**?_____ Yes _____ No

   If yes, check all that apply

   a. Will it **BENEFIT** your community? _____Yes _____ No

   b. Will it **BURDEN** your community? _____Yes _____ No

   i. If the respondent said benefits, **WHAT** do you see as the **BENEFITS** of these toll roads?

   ____

   ____

   ii. If the respondent said burdens, **WHAT** do you see as the **BURDENS** of these toll roads?

   ____

   ____

   iii. If the respondent said burdens, **WHAT** can **TxDOT** do to **REDUCE** or **ELIMINATE** these **BURDENS**?

   ____

   ____

Do YOU WANT to be INVOLVED?

7. Can we **CONTACT YOU IN THE FUTURE** to find out what you think about toll roads?

   _____ Yes _____ No

8. If yes, What is the **BEST WAY TO REACH YOU**? ___ Come to my home ___ Send a questionnaire

   ____ Phone me ___ Interview me at the shopping mall/grocery store ___ Come to my church

   ____ Come to one of the schools in the community

   ____ Other way. How? ____

9. Is there **ANYONE** in your community that **CAN SPEAK FOR THE COMMUNITY**?

   _____Yes _____No

10. If yes, Could you please **SHARE HIS/HER NAME** with us? ______________________________

Personal Information (depending on answer to questions 7 and 8)

Name: ____Telephone: ________________

Address: ____

ADDITIONALCOMMENTS: ____

____

Figure B.4 Questionnaire 2 and Accompanying Map, continued

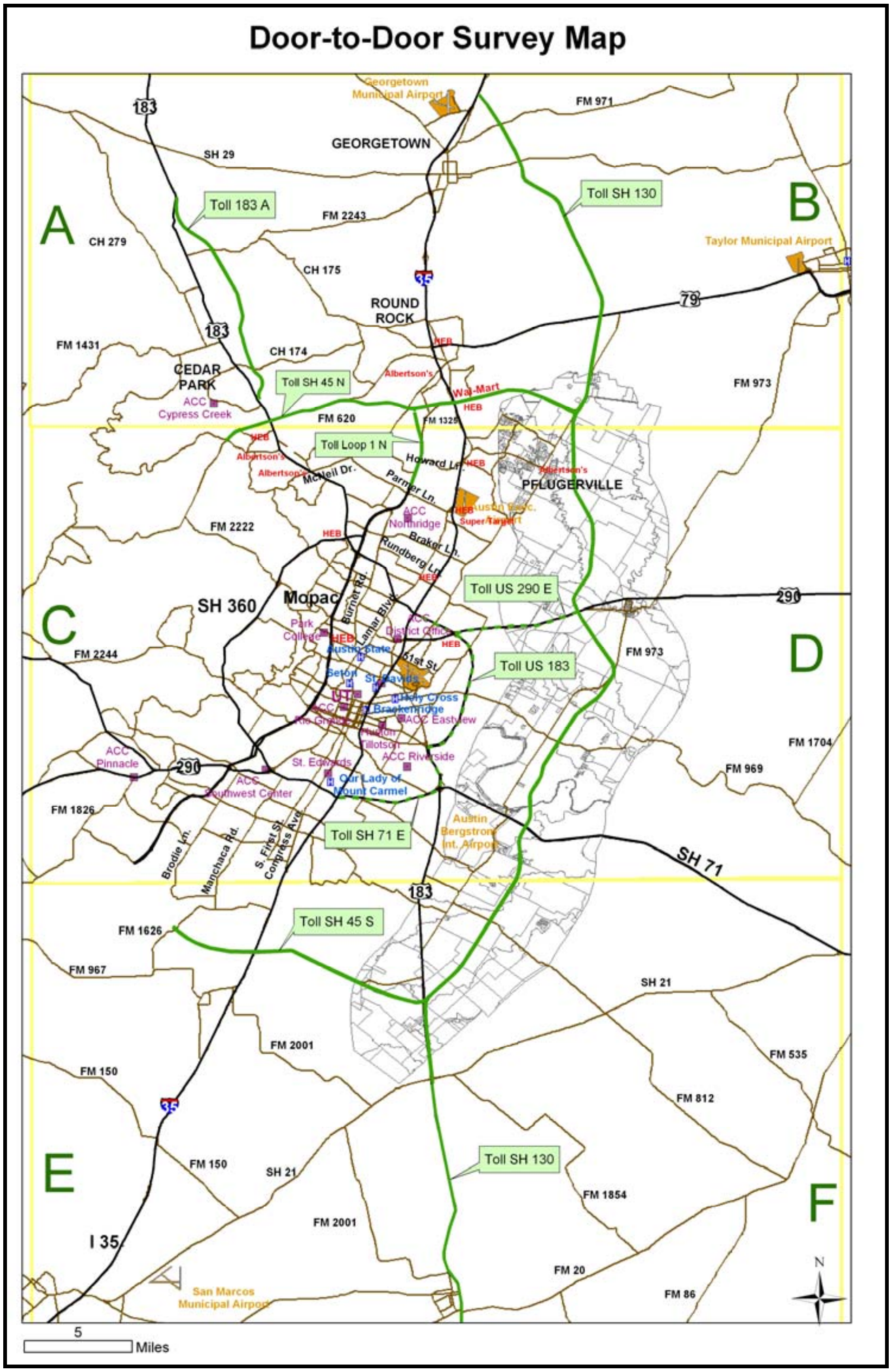


Figure B.4 Questionnaire 2 and Accompanying Map, continued

B.2 Survey Results and Interpretation

B.2.1 Effective Response Rate

Table B.2 summarizes the response rates by survey site and overall. In all cases, the response rates exceeded 25%. Sites 3 and 5 yielded the highest response rates at 44% and 43% respectively. An overall response rate of 34% was achieved.

Table B.2 Response Rate by Surveys Site and Overall

Site	Sampled Housing Units	Non-Reachable Housing Units*	Surveyed Housing Units	Response Rate (%)
1 (Pflugerville)	179	127	52	29
2 (Pflugerville)	200	148	52	26
3 (Manor)	127	71	56	44
4 (FM-973 & SH-812)	84	52	32	38
5 (FM-973 & SH-71)	112	64	48	43
TOTAL =	702	462	240	34

*Non-reachable housing units include residences that did not open the door or refused to participate in the survey.

B.2.2 Type of Survey

Table B.3 shows the number of completed surveys by questionnaire type. Based on the total number of completed surveys, 57% of the respondents (136 housing units) completed questionnaire 1 while 43% (104 housing units) completed questionnaire 2.

Table B.3 Completed Surveys by Questionnaire Type

Site	Date	Questionnaire 1	Questionnaire 2
1 (Pflugerville)	03/25/06	50	2
2 (Pflugerville)	03/26/06	0	52
3 (Manor)	03/15/06	56	0
4 (FM-973 & SH-812)	04/01/06	1	31
5 (FM-973 & SH-71)	04/01/06-04/02/06	29	19
	TOTAL =	136	104

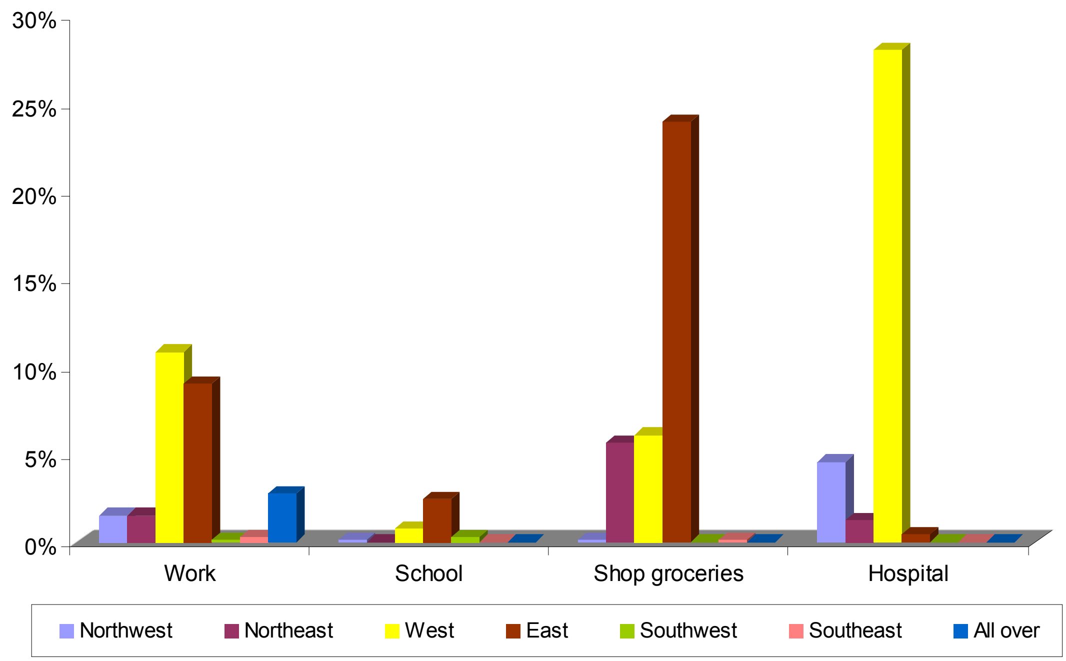
B.2.3 Trip Purpose

Analysis of the data reveals that 71% of the respondents work and that 24% of the respondents attend a school.

B.2.4 Trip Purpose by Region

Figure B.5 illustrates where the respondents indicated they work, go to school, shop for groceries, or go to the hospital. Based on Figure B.5, the following observations can be made:

- Most of the respondents indicated trip destinations (i.e., work, school, grocery shopping, and hospital) in the West (46%) and the East (36%) regions specified in the door-to-door survey map.
- Most respondents work in the West and East regions specified in the door-to-door survey map. Also, most of the respondents shop for groceries (approximately 67% of total shopping destinations) and go to school (approximately 67% of total school destination) in the East region.
- From Figure B.5 it is also evident that the Northwest, Northeast, Southwest, and Southeast regions are not major destinations for work, school, grocery shopping, or hospital trips.



Trip Purpose	Northwest (Area A)*		Northeast (Area B)		West (Area C)		East (Area D)	
Work	10	1.5%	10	1.5%	71	10.8%	59	9.0%
School	1	0.2%	0	0.0%	5	0.8%	16	2.4%
Shop Groceries	1	0.2%	37	5.6%	40	6.1%	157	23.9%
Hospital	30	4.6%	8	1.2%	184	28.0%	3	0.5%
TOTAL =	42	6.4%	55	8.4%	300	45.7%	235	35.8%
Trip Purpose	Southwest (Area E)		Southeast (Area F)		All over (Area G)		Total	
Work	1	0.2%	2	0.3%	18	2.7%	171	
School	2	0.3%	0	0.0%	0	0.0%	24	
Shop Groceries	0	0.0%	1	0.2%	0	0.0%	236	
Hospital	0	0.0%	0	0.0%	0	0.0%	225	
TOTAL =	3	0.5%	3	0.5%	18	2.7%	656	

*See Door-to-Door Survey Map

Figure B.5 Trip Purpose by Region

B.2.5 Trip Purpose by Transportation Mode

Figure B.6 illustrates the transportation mode used by respondents for work, school, grocery shopping, and hospital trips.

Trip Purpose	Drive Alone		Carpool		Bus		Walk		Work At Home		Other		Total
Work	145	22.1%	10	1.5%	3	0.5%	2	0.3%	7	1.1%	4	0.6%	171
School	18	2.7%	1	0.2%	5	0.8%	0	0.0%	0	0.0%	0	0.0%	24
Shop Groceries	208	31.7%	24	3.7%	1	0.2%	2	0.3%	0	0.0%	1	0.2%	236
Hospital	197	30.0%	22	3.4%	1	0.2%	5	0.8%	0	0.0%	0	0.0%	225
TOTAL =	568	86.6%	57	8.7%	10	1.5%	9	1.4%	7	1.1%	5	0.8%	656

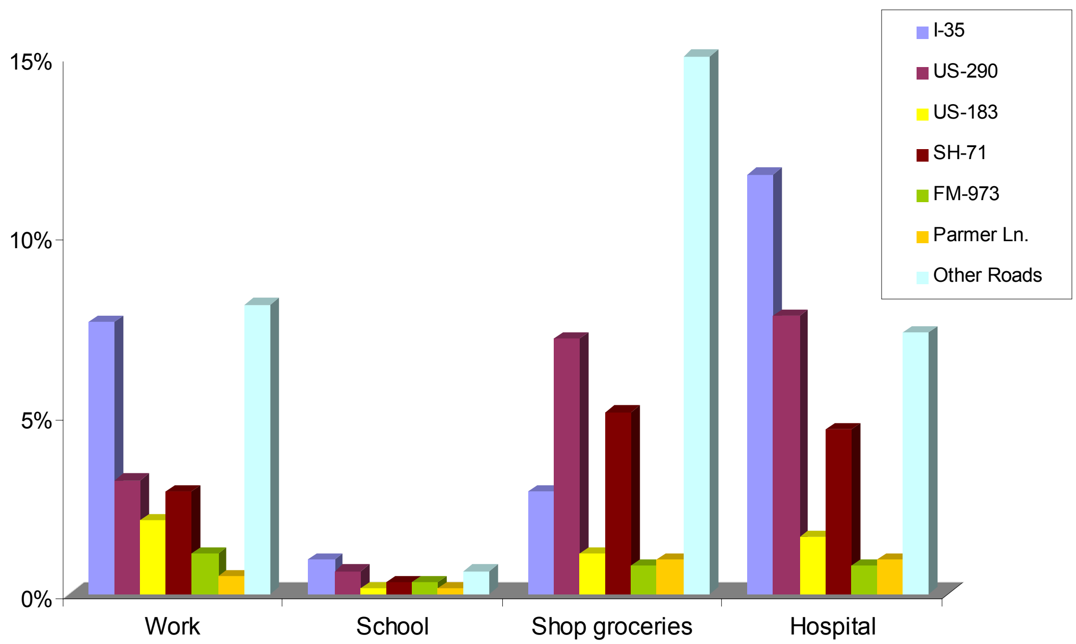
Figure B.6 Trip Purpose by Transportation Mode

Based on Figure B.6, the following observations can be made:

- *Drive alone* is the predominant mode of transportation (87%) used by respondents. About 9% of the respondents indicated they share driving responsibilities with others (i.e., carpool) and 2% indicated they ride the bus. Only 1% of the respondents indicated walking as their mode of transportation.

B.2.6 Major Roads by Trip Purpose

Figure B.7 shows the major roads used by respondents to get to work, school, grocery stores, and hospitals.



Trip Purpose	I-35		US-290		US-183		SH-71	
Work	48	7.6%	20	3.2%	13	2.1%	18	2.8%
School	6	0.9%	4	0.6%	1	0.2%	2	0.3%
Shop groceries	18	2.8%	45	7.1%	7	1.1%	32	5.1%
Hospital	74	11.7%	49	7.8%	10	1.6%	29	4.6%
TOTAL =	146	23.1%	118	18.7%	31	4.9%	81	12.8%
Trip Purpose	FM-973		Parmer Ln.		Other Roads		**OVERALL**	
Work	7	1.1%	3	0.5%	51	8.1%	160	
School	2	0.3%	1	0.2%	4	0.6%	20	
Shop groceries	5	0.8%	6	0.9%	120	19.0%	233	
Hospital	5	0.8%	6	0.9%	46	7.3%	219	
TOTAL =	19	3.0%	16	2.5%	221	35.0%	632	

Figure B.7 Major Roads Used by Respondents by Trip Purpose

From Figure B.7, the following observations can be made:

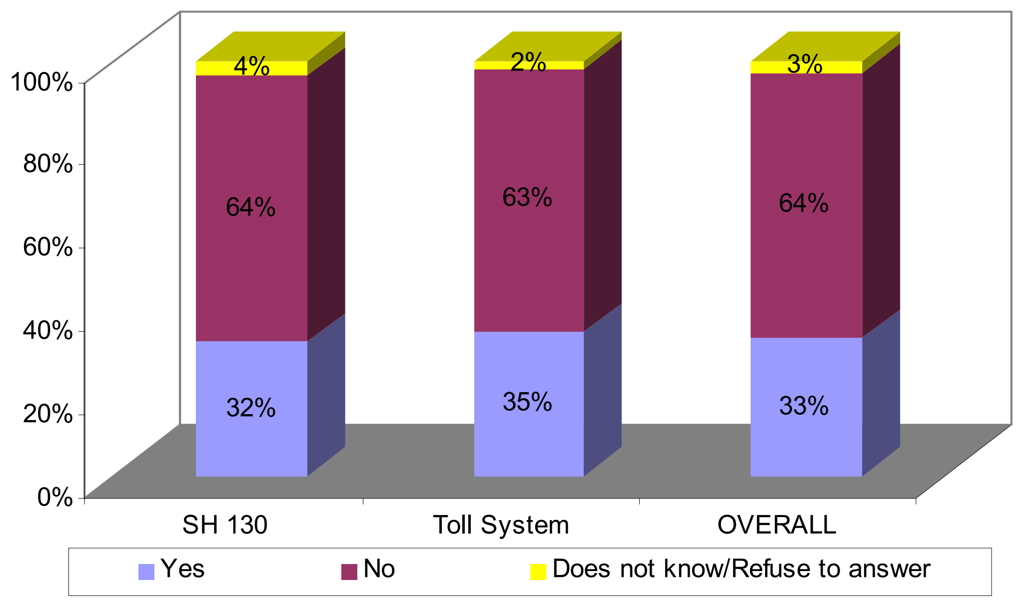
- Respondents mainly use I-35, US-290, and SH-71 to travel to work, school, grocery stores, and hospitals.
- From the survey responses it appears that the respondents will not travel on the SH 130 toll road. Although the toll road does not seem to provide an alternative road given the respondents' origin-destination patterns, residents benefit if a substantial volume of through traffic currently using I-35 is diverted to SH 130. On the other hand, the proposed toll lanes in the median of US 290, US 183 and SH 71 have the potential to impact the respondents' trips.

B.2.7 Foreseen Impacts on Trips Imposed by Toll Road(s)

Figure B.8 summarizes the gathered responses regarding whether the respondent's trips will be impacted by the proposed toll road(s). From Figure B.8, the following is evident:

- Overall, about one-third of the respondents (33%) indicated that the toll road(s) will impact one or more of the types of trips listed (i.e., work, school, grocery shopping, or hospital), 64% indicated no impact on their trips, and 3% refused to answer the question or did not know if or how the toll road(s) will impact their trips.
- As expected, a higher percentage of the surveyed respondents (35% compared to 32%) indicated that their trips will be impacted by the system of toll roads compared to the single toll road (i.e., SH 130). To determine if the latter was statistically significant at the 99% confidence level, the differences between

population proportions were tested assuming the test statistic has a standard normal distribution. The outcome revealed that the population proportion perceived to be impacted by the SH 130 is statistically significantly less than the toll road system at a 0.01 significance level ($observed\ Z = -0.368 > -Z_{0.01} = -2.326$, p-value>0.01).

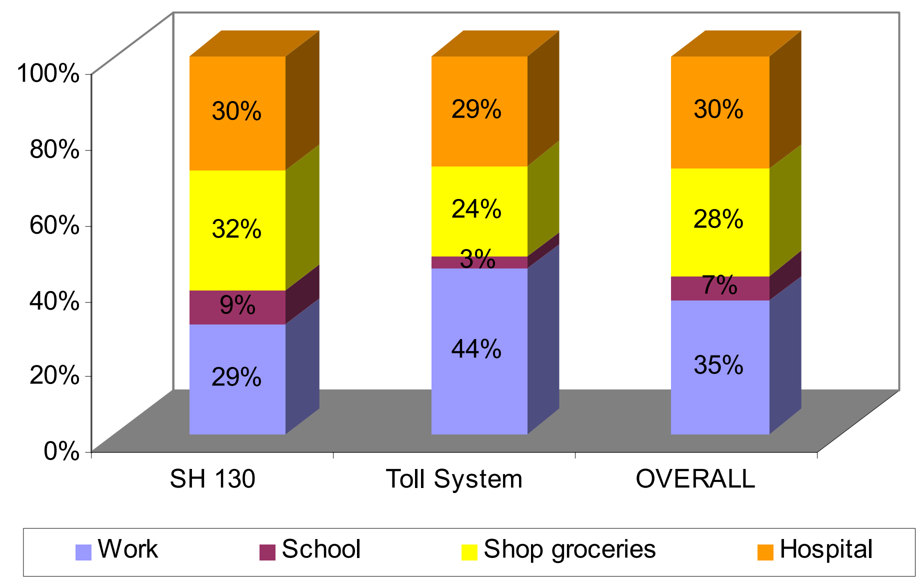


Will toll road affect your trips?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	44	32%	36	35%	80	33%
No	87	64%	66	63%	153	64%
Does not know/Refuse to answer	5	4%	2	2%	7	3%
TOTAL =	136	100%	104	100%	240	100%

Figure B.8 Results about whether Respondent's Trips Will Be Impacted by the Proposed Toll Road(s)

B.2.8 Trips Purposes Potentially Impacted by the Proposed Toll Road(s)

Figure B.9 illustrates the trip purposes that will be impacted by the proposed toll road(s), as perceived by the respondents.



Trips to:	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Work	22	29%	27	44%	49	35%
School	7	9%	2	3%	9	7%
Shop groceries	24	32%	15	24%	39	28%
Hospital	23	30%	18	29%	41	30%
TOTAL =	76	100%	62	100%	138	100%

Figure B.9 Respondents' Trips Affected by the Proposed Toll Roads

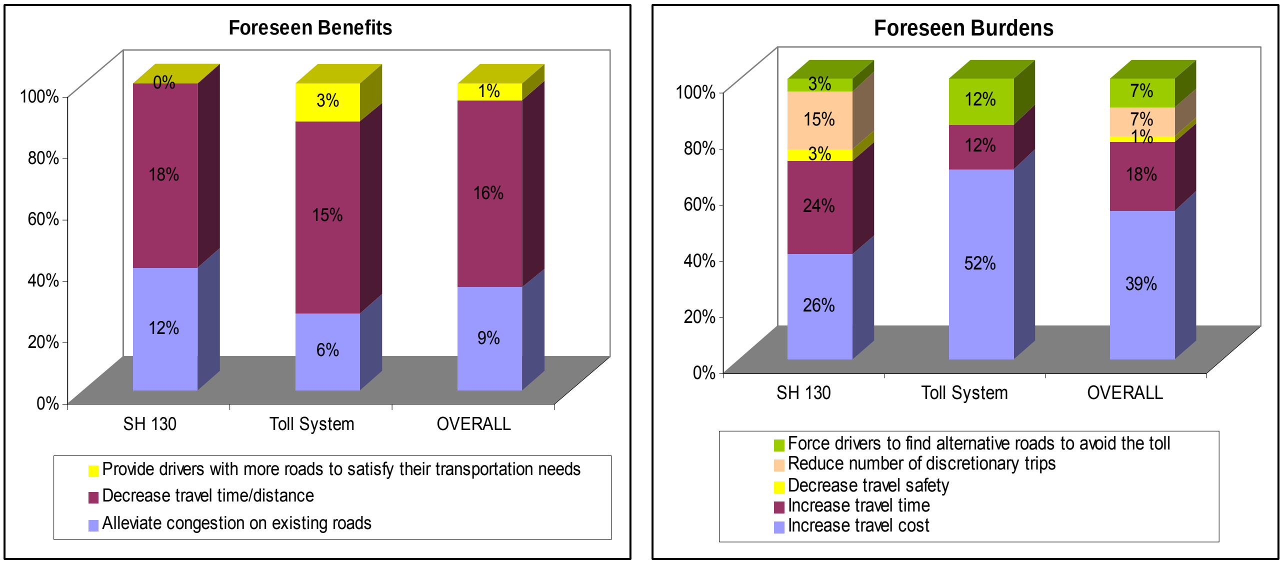
From Figure B.9, the following observations can be made:

- Overall, most respondents indicated that their work trips will be impacted (35%), followed by their trips to the hospital (30%) and to grocery stores (28%). Trips to school seem to be less impacted by the toll road(s) (7%).

- As expected, a higher percentage of the respondents indicated that the toll system (consisting of 183A, SH 45N, Loop 1N, US 290E, US 183, SH 71E, SH 45S, and SH 130) will impact their trips to work compared to the SH 130 toll road (44% compared to 29%). This finding was statistically significant at the 99% confidence level ($observed\ Z = -1.783 > -Z_{0.01} = -2.326$, p-value > 0.01) but not at the 95% confidence level ($observed\ Z = -1.783 < -Z_{0.05} = -1.645$, p-value < 0.05).
- A higher percentage of respondents indicated that the SH 130 toll road will impact their trips to grocery stores (32%) compared to the toll system (24%). This finding was statistically significant at the 99% confidence level ($observed\ Z = 0.958 < Z_{0.01} = 2.326$, p-value > 0.01). This was also true in the case of trips to hospital. A higher percentage of the respondents indicated that the SH 130 toll road will impact their trips to the hospital (30%) compared to the toll system (29%). This finding was statistically significant at the 99% confidence level ($observed\ Z = 0.157 < Z_{0.01} = 2.326$, p-value > 0.01).

B.2.9 Foreseen Impacts Imposed by the Toll Roads

Figure B.10 summarizes the foreseen impacts imposed by toll road(s) on their trips as listed by respondents.



FORESEEN BENEFITS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Alleviate congestion on existing roads	4	12%	2	6%	6	9%
Decrease travel time/distance	6	18%	5	15%	11	16%
Provide drivers with more roads to satisfy their transportation needs	0	0%	1	3%	1	1%
SUB-TOTAL=	**10**	**29%**	**8**	**24%**	**18**	**27%**
FORESEEN BURDENS	**SH 130**		**Toll System**		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Increase travel cost	9	26%	17	52%	26	39%
Increase travel time	8	24%	4	12%	12	18%
Decrease travel safety	1	3%	0	0%	1	1%
Reduce number of discretionary trips	5	15%	0	0%	5	7%
Force drivers to find alternative roads to avoid the toll	1	3%	4	12%	5	7%
SUB-TOTAL =	**24**	**71%**	**25**	**76%**	**49**	**73%**
TOTAL =	34	100%	33	100%	67	100%

Figure B.10 Foreseen Impacts Imposed by Toll Road(s) on Respondents' Trips

Based on Figure B.10, the following observations can be made:

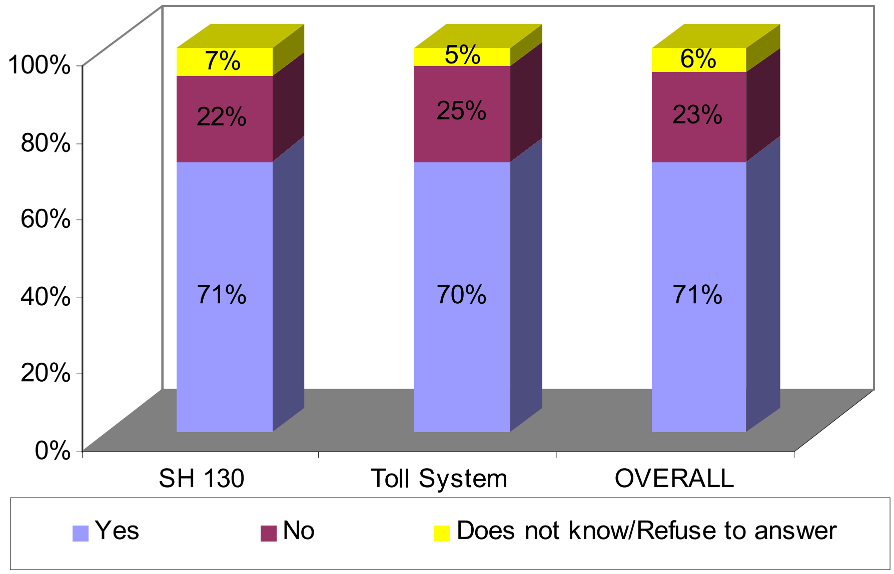
- Overall, 73% of the responses pertained to foreseen burdens while the remaining 27% of the responses pertained to foreseen benefits.

- The respondents associated more burdens on their activity space (e.g., work, school, grocery shopping, and hospital trips) with the toll road system in Central Texas (e.g., 183A, SH 45N, Loop 1N, US 290E, US 183, SH 71E, SH 45S, and SH 130) as compared to the SH 130 toll road (76% of the responses compared to 71% of the responses). This finding was statistically significant at the 99% confidence level ($\textit{observed}\ Z = -0.477 > -Z_{0.01} = -2.326$, p-value > 0.01). Also, the respondents associated fewer benefits with the toll road system as compared to the SH 130 toll road (24% of the responses compared to 29% of the responses). This finding was also statistically significant at the 99% confidence level ($\textit{observed}\ Z = 0.477 < Z_{0.01} = 2.326$, p-value > 0.01).
- Overall, the respondents foresee that the added capacity provided by the toll roads will help to reduce travel time and distance (16% of the responses) and alleviate congestion on existing roads (9% of the responses). A few of the respondents mentioned that the toll road(s) will reduce traffic on I-35 and FM 973.
- Overall, the respondents foresee that the toll road(s) will increase their travel cost (39% of the responses) and travel time (18% of the responses). In terms of travel cost, the respondents foresee the following burdens: (a) in the future drivers have to pay for using the SH 290, which is "free" at present, (b) on Sundays, the cost of trips to church will increase if the toll road(s) is used, and (c) the toll road(s) will increase the travel cost of local business customers. In terms of travel times, the respondents mentioned the following burdens: (a) the toll road(s) will attract more vehicles to the area, (b) drivers will have to stop to pay for the toll, and (c) drivers avoiding the toll road(s) will increase traffic on local streets.

- Overall, 14% of the responses concerned the fact that toll road(s) would force the respondents to limit their discretionary trips and seek alternative roads to avoid the toll(s). Some respondents feel that they may have to change the places where they shop.
- None of the respondents remarked that the SH 130 toll road would provide them with an additional road to satisfy their transportation needs while only one respondent noted that the toll road system in Central Texas will provide more options to satisfy his transportation needs.
- Respondents seem to be more concerned about the travel cost imposed by the Central Texas toll road system (e.g., 183A, SH 45N, Loop 1N, US 290E, US 183, SH 71E, SH 45S, and SH 130) as opposed to the travel cost imposed by the SH 130 toll road (52% of the responses compared to 26% of the responses). On the other hand, the responses seem to suggest that respondents are more concerned about the increased travel time impacts imposed by the SH 130 (24% of the responses) compared to the toll road system in Central Texas (12% of the responses).
- Respondents are more concerned about the impacts on discretionary trips imposed by the SH 130 toll road than by the toll road system. On the other hand, the results suggest that respondents recognize that the toll road system will force drivers to find alternate roads (12% of the respondents) more so than in the case of a single toll road (3% of the respondents).

B.2.10 Potential Community Impacts Imposed by Toll Roads

Figure B.11 summarizes the gathered responses regarding whether the respondents' communities will be impacted by the proposed toll road(s).



Will toll roads affect your community?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	96	71%	73	70%	169	71%
No	30	22%	26	25%	56	23%
Does not know/Refuses to answer	10	7%	5	5%	15	6%
TOTAL =	136	100%	104	100%	240	100%

Figure B.11 Results about whether Respondents' Community Will Be Impacted by the Proposed Toll Road(s)

Based on Figure B.11, the following observations can be made:

- Overall, 71% of the respondents indicated that the proposed toll road(s) will impact their communities while 23% indicated the toll road(s) will not impact their communities. Only 6% of the respondents refused to answer the question or did not know how the proposed toll road(s) will impact their communities.
- Although a similar percentage of respondents foreseen that the SH 130 toll road and the toll system in Central Texas will impact their communities (71% and 70% of the respondents respectively), the statistical test at the 99%

confidence level revealed that a statistically significantly higher number of respondents indicated that the SH 130 toll road will impact their communities compared to the system of toll roads in Central Texas ($observed\ Z = 0.067 < Z_{0.01} = 2.326$, p-value > 0.01).

- A higher percentage of respondents (25%) indicated that the system of toll roads in Central Texas will not impact their communities compared to the SH 130 toll road (22%). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.477 > -Z_{0.01} = -2.326$, p-value > 0.01).

Table B.4 summarizes the gathered responses regarding whether the proposed toll road(s) will impact respondents' trips (Question 5a) and communities (Question 6). The following observations can be made:

- Overall, 71% of the respondents indicated that the proposed toll road(s) will impact their communities—more than twice the number of respondents who indicated that the toll road(s) will impact their trips (33% of the respondents).
- Fewer respondents did not know or refused to answer when asked about the impacts of the toll road system in Central Texas upon their trips than when asked about the SH 130 toll road (2% and 4%, respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = 0.800 < Z_{0.01} = 2.326$, p-value>0.01). Also, fewer respondents did not know or refused to answer when asked about the impacts of the toll road system in Central Texas upon their communities than when asked about the SH 130 toll road (5% and 7%, respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = 0.807 < Z_{0.01} = 2.326$, p-value>0.01). This finding could suggest that it was easier for the

respondents to visualize the impacts of the system of toll roads on their trips and communities than the impacts imposed by a single toll road.

Table B.4 Results about whether Toll Road(s) Will Impact Respondents' Trips/Community

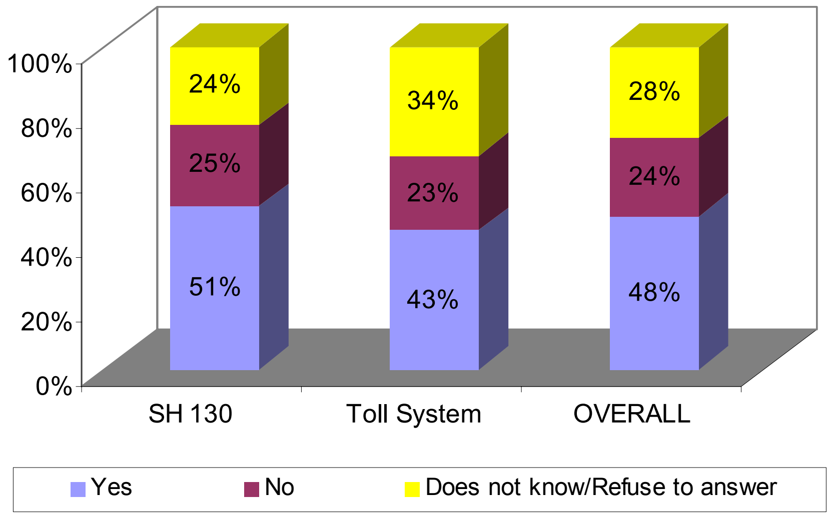
Will toll road(s) affect your trips?								
YES			**NO**			**Does not know/Refuses to answer**		
SH 130	Toll System	Overall	SH 130	Toll System	Overall	SH 130	Toll System	Overall
32%	35%	33%	64%	63%	64%	4%	2%	3%
Will toll road(s) affect your community?								
YES			**NO**			**Does not know/Refuses to answer**		
SH 130	Toll System	Overall	SH 130	Toll System	Overall	SH 130	Toll System	Overall
71%	70%	71%	22%	25%	23%	7%	5%	6%

Note: Based on 240 responses

B.2.11 Will Proposed Toll Roads Benefit Respondents' Community?

Figure B.12 summarizes the gathered responses regarding whether the respondents' community will benefit from the proposed toll road(s). Based on Figure B.12, the following observations can be made:

- Overall, 48% of the respondents indicated that the toll road(s) will benefit their communities while 24% did not foresee any benefits from the toll road(s). About 28% of the respondents refused to answer or did not know. This was especially the case for those surveyed about the toll road system in Central Texas (i.e., 34% of the respondents did not know whether the proposed toll road(s) will benefit their communities or refused to answer this question). This could point to the need for increased public information to inform and educate communities about the proposed toll road system in Central Texas.



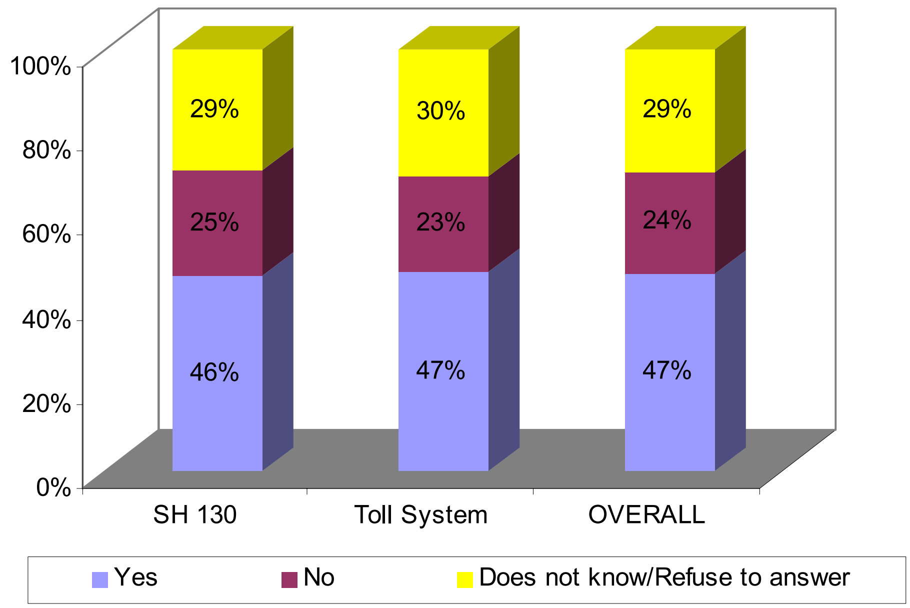
Will the toll road(s) benefit your community?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	69	51%	45	43%	114	48%
No	34	25%	24	23%	58	24%
Does not know/Refuses to answer	33	24%	35	34%	68	28%
TOTAL =	136	100%	104	100%	240	100%

Figure B.12 Results abut whether Respondents' Community Will Benefit from Proposed Toll Road(s)

- A higher percentage of the respondents indicated that the SH 130 toll road will benefit their communities (51%) compared to the toll road system in Central Texas (43%). This finding was statistically significant at the 99% confidence level ($\mathit{observed}\ Z = 1.148 < Z_{0.01} = 2.326$, p-value>0.01).
- At the same time, a higher percent of respondents indicated that the SH 130 toll road will not benefit their communities (25%) compared to the toll road system in Central Texas (23%). This finding was statistically significant at the 99% confidence level ($\mathit{observed}\ Z = 0.345 < Z_{0.01} = 2.326$, p-value>0.01).

B.2.12 Will Proposed Toll Roads Burden Respondents' Communities? (Question 6b)

Figure B.13 summarizes gathered responses regarding whether the respondents' communities will burden by the proposed toll road(s).



Will toll road(s) burden your community?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	63	46%	49	47%	112	47%
No	34	25%	24	23%	58	24%
Does not know/Refuse to answer	39	29%	31	30%	70	29%
TOTAL =	136	100.0%	104	100%	240	100%

Figure B.13 Results about whether Respondents' Community Will Be Burdened by the Proposed Toll Road(s)

Based on Figure B.13, the following observations can be made:

- Overall, 47% of the respondents indicated that the toll road(s) will burden their communities while 24% did not foresee any burdens imposed by the toll road(s). About 29% of respondents did not know whether the proposed toll road(s) will burden their communities or refused to answer this question.

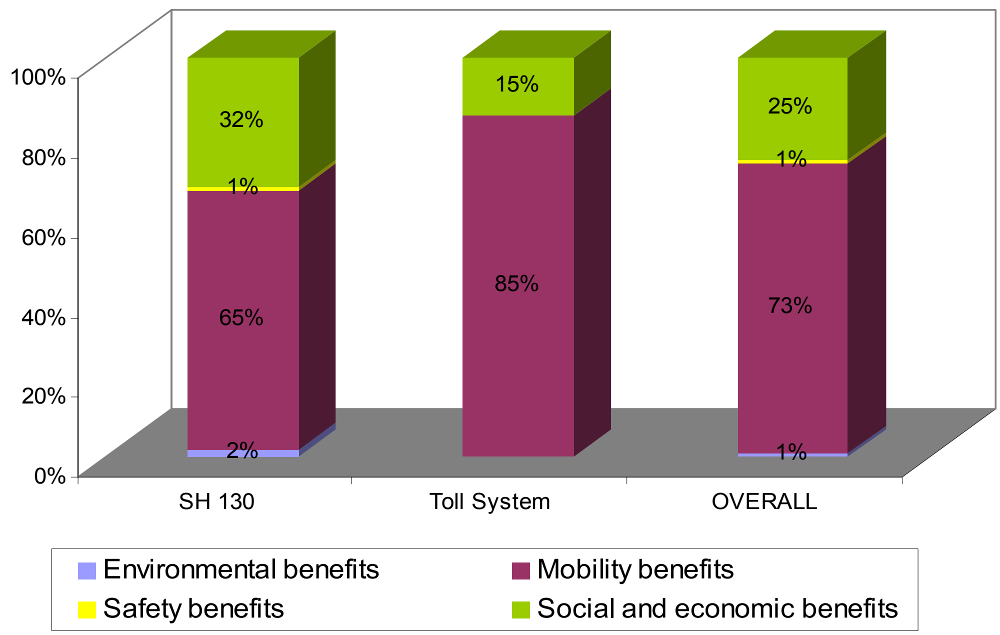
- The results were similar when respondents were asked about the burdens imposed by the toll road system in Central Texas and the SH 130 toll road. Around 46% of the respondents indicated that the toll road(s) will burden their communities and around 24% indicated that the toll road(s) will not burden their communities.

B.2.13 Foreseen Community Benefits Imposed by Toll Road(s)

Figure B.14 summarizes the gathered responses regarding foreseen benefits the proposed toll road(s) may have on the surveyed community. The respondents provided 106 responses when asked about the foreseen benefits from toll road(s) on their communities. The following observations can be made:

- Overall, the respondents indicated that the toll road(s) will provide improved surface mobility (73% of the responses), an increase in social and economic benefits (25% of the responses), an improved environment (1% of the responses), and enhanced highway safety (1% of the responses).
- The results suggest the toll road system in Central Texas is perceived to provide more mobility benefits compared to the SH 130 toll road (85% of the responses compared to the 65% of the responses). This finding, however, was not statistically significant at the 99% confidence level ($\textit{observed } Z = -2.334 < -Z_{0.01} = -2.326$, p-value < 0.01).
- The SH 130 toll road is perceived to provide more social and economic benefits than would the toll road system in Central Texas (32% of the responses compared to 15% of the responses). This finding was statistically

significant at the 95% confidence level (p-value > 0.05) but not at the 99% confidence level (p-value < 0.01). Overall, 22% of the responses indicated that the toll road(s) will attract new businesses to the region and 4% of the responses indicated that the toll road(s) will increase property values.



BENEFITS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Environmental benefits	1	2%	0	0%	1	1%
Mobility benefits	42	65%	35	85%	77	73%
Safety benefits	1	1%	0	0%	1	1%
Social and economic benefits	21	32%	6	15%	27	25%
TOTAL =	65	100%	41	100%	106	100%

Note: Environmental benefits relate to less pollution. Mobility benefits comprise reduced traffic on congested roads, faster roads, and more options for drivers. Safety benefits include fewer traffic accidents. Finally, social and economic benefits include attracting new businesses and increasing property values.

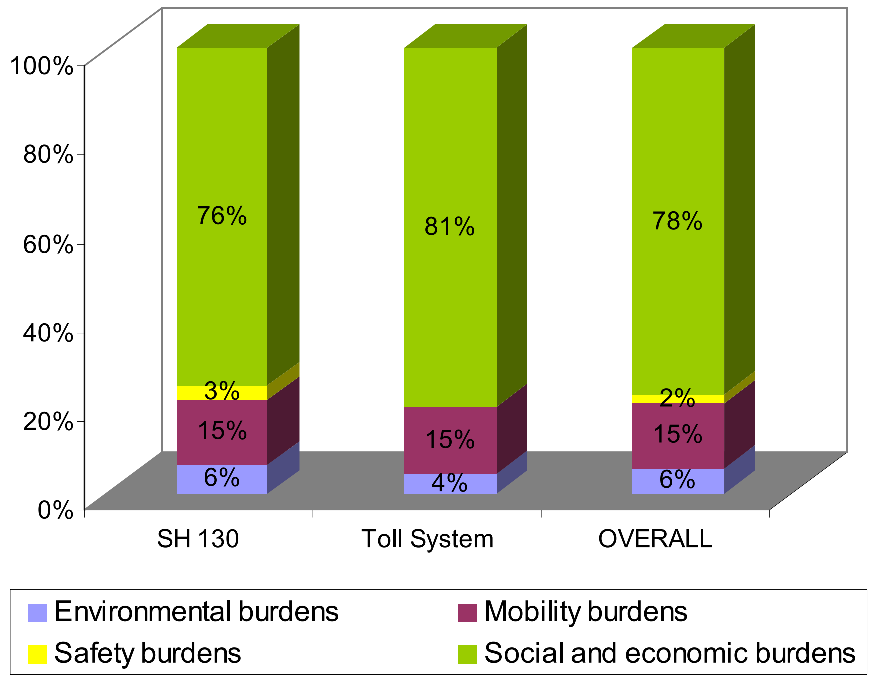
Figure B.14 Foreseen Community Benefits from Proposed Toll Road(s)

- Overall, 43% of the responses referred to a reduction in traffic on congested roads such as I-35, SH 290 and Loop 1 (Mopac). Some respondents mentioned that the SH 130 toll road will reduce truck traffic on I-35. In addition, 21% of the responses indicated that the toll road(s) will provide faster routes compared with the existing roads.

B.2.14 Foreseen Community Burdens Imposed by Toll Road(s)

Figure B.15 summarizes the gathered responses regarding foreseen burdens the proposed toll road(s) may have on the surveyed community. The respondents provided 109 responses when asked to list the potential burdens imposed by the toll road(s) on their communities. The following observations can be made:

- The respondents indicated that the toll road(s) will have a negative impact on the social and economic aspects of their communities (78% of the responses), their mobility (15% of the responses), the physical environment (6% of the responses), and highway safety (2% of the responses).
- The results suggest that more respondents were concerned about the social and economic burdens imposed by the toll system in Central Texas than the social and economic burdens imposed by the SH 130 toll road (81% and 76% of the responses respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.629 > -Z_{0.01} = -2.326$, p-value>0.01).



BURDENS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Environmental burdens	4	6%	2	4%	6	6%
Mobility burdens	9	15%	7	15%	16	15%
Safety burdens	2	3%	0	0%	2	2%
Social and economic burdens	47	76%	38	81%	85	78%
TOTAL =	62	100%	47	100%	109	100%

Note: The environmental burdens listed relate to increased air pollution/traffic noise, and increase of flooding areas. Mobility burdens mentioned by respondents include increased traffic jams in areas close to construction zones, worsened traffic conditions on entry/exit ramps, increased trip length, slower traffic due to toll booths, and increased traffic ticketing. The safety burdens listed relate to an increase in traffic accidents. Finally, the social and economic burdens listed include the following: affect driver's transportation budget, increase traffic through neighborhoods, affect quality of life in the community, increase driver's stress, hamper community cohesion, encourage community segregation by income level, decrease property values of homes near toll roads, necessitate relocation of homes and businesses, and increase property taxes.

Figure B.15 Foreseen Community Burdens Imposed by Proposed Toll Road(s)

- The most often cited social and economic burden was the impact that the toll road(s) will have on the driver's budget (43% of the responses) because drivers have to pay for using the toll road(s). Also a number of respondents feel that the toll road(s) will negatively impact the quality of life in their communities by attracting more people to the area (18% of the responses).

B.2.15 Mitigation Options Proposed to Minimize or Eliminate the Identified Burdens

Table B.5 lists the mitigation options provided by the respondents to avoid or lessen the burdens imposed by the proposed toll road(s) on their communities.

Table B.5 Proposed Mitigation Options

MITIGATION OPTIONS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Do not build toll roads/Continue to pay for roads with tax dollars	12	40%	12	48%	24	44%
Put the toll road decision up to a vote	3	10%	3	12%	6	11%
Improve community outreach to inform and involve the community in the planning, design, and construction of toll roads	3	10%	2	8%	5	9%
Upgrade and improve existing non-toll roads for those who cannot afford the tolls (e.g., improve connectivity and safety of existing roads, improve traffic light management)	4	13%	1	4%	5	9%
Provide better public transportation for those who cannot afford the toll	2	7%	1	4%	3	5%
Provide "free passes" to those living near toll roads and low-income people who cannot afford the toll	1	3%	2	8%	3	5%
Only build toll road through commercial areas	1	3%	1	4%	2	4%
Do not allow truck traffic on toll roads	1	3%	1	4%	2	4%
Charge reasonable toll fees	1	3%	0	0%	1	2%
Build noise walls	0	0%	1	4%	1	2%
Provide tags so drivers do not have to stop to pay the toll	0	0%	1	4%	1	2%
Limit toll road construction to off-peak travel hours	1	3%	0	0%	1	2%
Relocate affected properties	1	3%	0	0%	1	2%
TOTAL =	30	100%	25	100%	55	100%

Based on Table B.5, the following observations can be made:

- Overall, the most frequently proposed mitigation option was to not build toll roads and/or continue to pay for roads with tax dollars (44% of the responses). Also, a number of respondents said that the toll road decision should be put up to a vote (11% of the responses).
- A higher percentage of the responses favored not building toll roads/continuing to pay for roads with tax dollars in the case of the Central Texas toll road system (48% of the responses) than for the SH 130 toll road (40% of the responses). This finding was statistically significant at the 99% confidence level ($\textit{observed } Z = -0.596 > -Z_{0.01} = -2.326$, p-value>0.01).
- Overall, the respondents listed better community outreach to inform and involve the community in the planning, design, and construction of toll road(s) (9% of the responses). This mitigation option comprised 10% of the responses when respondents were asked about SH 130 and 8% of the responses when respondents were asked about the toll road system in Central Texas.
- Overall, the respondents proposed improvements to the connectivity and safety of the non-toll existing roads so those who cannot afford the toll may have a comparable alternative to satisfy their transportation needs (9% of the responses). This option was listed by respondents who were asked about the SH 130 toll road (13% of the responses) and respondents who were asked about the toll road system in Central Texas (4% of the responses).
- Overall, the respondents also listed the provision of better public transportation in low-income areas so drivers who cannot afford the toll would have an alternative transportation mode (5% of the responses) and the

provision of “free passes” to those living near toll roads and low-income drivers who cannot afford the toll (5% of the responses). Regarding the latter, fewer respondents listed “free passes” as a potential mitigation option when asked about the SH 130 toll road (3% of the responses) than when asked about the toll road system in Central Texas (8% of the responses). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.759 > -Z_{0.01} = -2.326$, p-value>0.01).

Table B.6 relates the respondents’ answers to whether the toll road(s) will impact their trips (i.e., work, school, grocery shopping, and hospital) with the number of the identified impacts (i.e., benefits and burdens), and the listed possible mitigation options to reduce or eliminate the identified burdens.

Table B.6 Relationship Between Trip and Community Impacts and Ability to Identify Mitigation Options

Respondents who said toll road(s) will:	Total number of responses	Identified burdens (number of responses)	Identified mitigation options (number of responses)	Identified benefits (number of responses)
Affect any of their trips	80	49	36	17
Benefit the community	114	NA	NA	105
Burden the community	112	107	65	NA

From Table B.6 the following observations can be made:

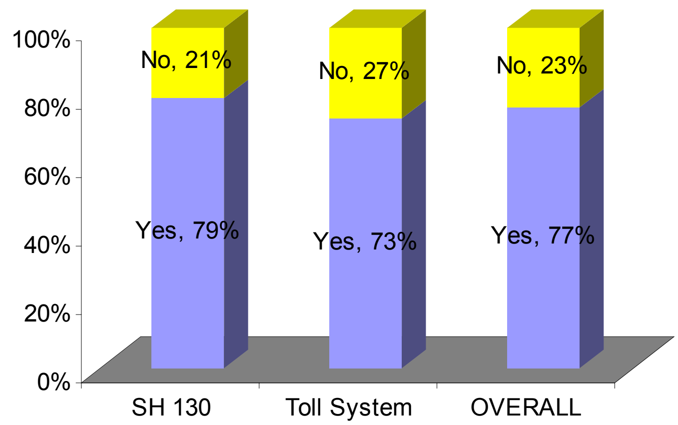
- The 80 respondents that indicated that the toll road(s) will impact their trips identify 49 burdens (responses) and list 36 mitigation options (responses) to avoid or mitigate the negative impacts imposed by the toll roads on their trips. Only 17 benefits associated with the proposed toll roads were provided by these respondents.

- The 114 respondents who said toll road(s) will benefit their communities were able to provide 105 benefits (responses).
- The 112 respondents who indicated that toll road(s) will burden their community could provide 65 measures (responses) to mitigate or avoid the negative impacts. This question had a relative low response rate, which might suggest the need for additional outreach activities to inform and involve the EJ communities in the decision-making process surrounding toll road(s) in Central Texas.

B.2.16 Willingness to Be Involved

Figure B16 summarizes the gathered responses regarding the respondents' willingness to be contacted in the future to obtain their input in the decision-making process surrounding toll road(s). From Figure H.16, the following observations can be made:

- Overall, 77% of the respondents indicated that they were amenable to being contacted in the future to provide input in the decision-making process surrounding toll road(s). The remaining 23% did not want to be contacted in the future.
- A higher percentage of respondents that were asked about the SH 130 toll road indicated that they can be contacted in future compared to the respondents that were asked about the toll road system in Central Texas (79% and 73%, respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = 1.150 < Z_{0.01} = 2.326$, p-value>0.01).



Can we contact you in the future?	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	108	79%	76	73%	184	77%
No	28	21%	28	27%	56	23%
TOTAL =	136	100%	104	100%	240	100%

Figure B.16 Respondents' Willingness to Be Contacted in the Future

Table B.7 related the respondents' answers to whether the proposed toll road(s) will impact their trips and community with their willingness to be contacted in future to provide input in the decision-making process surrounding the toll road(s).

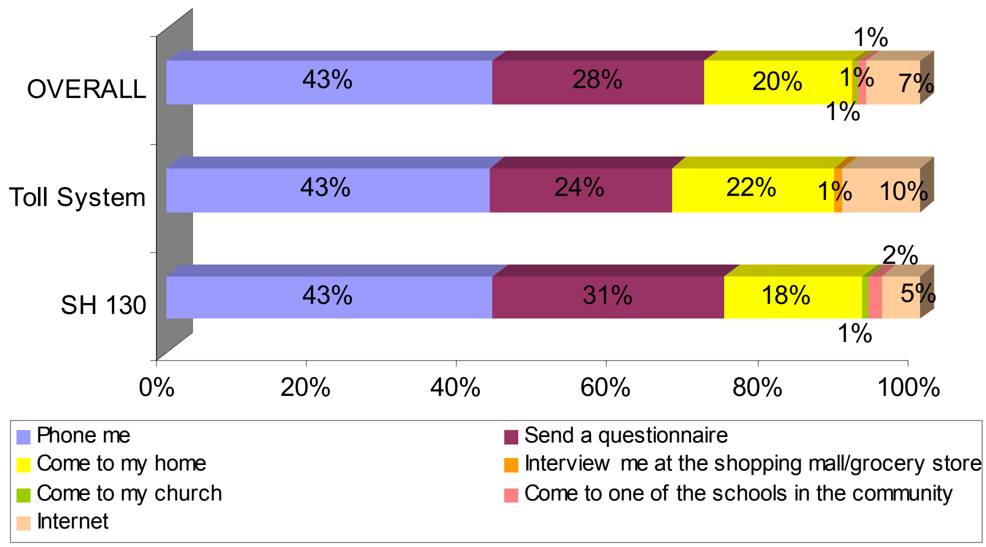
Table B.7 Relationship Between Trips and Community Impacts and Willingness to be Contacted in Future

Respondents who said toll road(s) will:	Willingness to be Contacted in Future				Valid Number of respondents
	Yes		No		
	Number of respondents	Percentage	Number of respondents	Percentage	
Affect any of their trips	66	83%	14	18%	80
Benefit the community	83	73%	31	27%	114
Burden the community	87	78%	25	22%	112

From Table B.7 is evident that more than 80% of the respondents who indicated that the proposed toll road(s) will impact their trips and 78% of the respondents who indicated that the proposed toll road(s) will burden their communities indicated a willingness to provide input in the decision-making process surrounding toll road(s) in Central Texas in the future.

B.2.17 Preferred Participation Techniques

Figure B.17 summarizes the preferred community participation techniques listed by respondents to provide input regarding proposed toll road(s). Overall, the community participation techniques preferred by the respondents were ‘phone me’ (43% of the responses), ‘send a questionnaire’ (28% of the responses), and ‘come to my home’ (20% of the responses). On the other hand, the less preferred participation techniques were ‘interview me at the shopping mall/grocery store’ (1% of the responses), ‘come to my church’ (1% of the responses), and ‘come to one of the schools in the community’ (1% of the responses). Only 1% of the surveyed people choose these options. Also, 7% of the respondents indicated that the best way to contact them was through electronic mail (i.e., Internet).

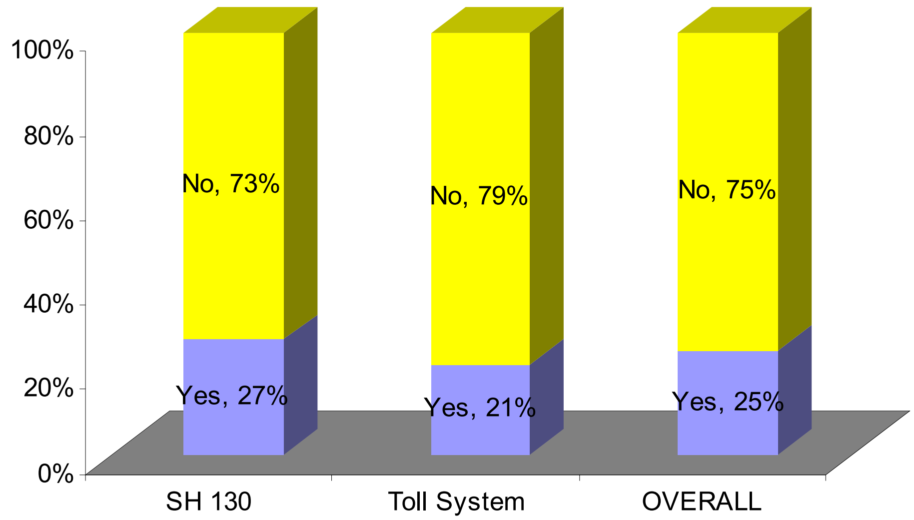


Community Outreach Efforts	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Phone me	52	43%	34	43%	86	43%
Send a questionnaire	37	31%	19	24%	56	28%
Come to my home	22	18%	17	22%	39	20%
Interview me at the shopping mall/grocery store	0	0%	1	1%	1	1%
Come to my church	1	1%	0	0%	1	1%
Come to one of the schools in the community	2	2%	0	0%	2	1%
Internet (e-mail)	6	5%	8	10%	14	7%
TOTAL =	120	100%	79	100%	199	100%

Figure B.17 Preferred Community Outreach Efforts

B.2.18 Leaders in the Community

Figure B.18 summarizes the gathered responses regarding whether the respondents could identify a community leaders that could speak on behalf of the impacted community.



Anyone can speak for the community	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	37	27%	22	21%	59	25%
No	99	73%	82	79%	181	75%
TOTAL =	136	100%	104	100%	240	100%

Survey Site	Yes		No	
	Responses	Percent	Responses	Percent
Site 1 (Pflugerville)	9	15%	43	24%
Site 2 (Pflugerville)	13	22%	39	21%
Site 3 (Manor)	22	37%	34	19%
Site 4 (FM-973 & FM-812)	6	11%	26	15%
Site 5 (FM-973 & SH-71)	9	15%	39	21%
TOTAL =	59	100%	181	100%

Figure B.18 Leaders in the Community

From Figure B.18, the following observations can be made:

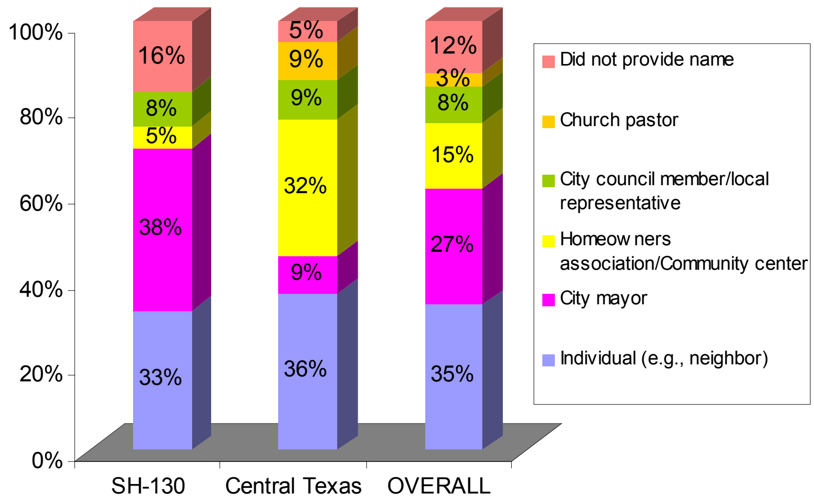
- Overall, 25% of the respondents indicated that there was someone in the community that could speak for the community, while 75% said that there was no one that could speak for the community.
- It is evident that 37% of the respondents in Manor said that there was someone that could speak for the community. Also, at Site 2 (Pflugerville),

22% of the respondents indicated that there was someone that could speak for the community. At the three remaining sites, however, 60% of the respondents said that there was no one that could speak for the community.

B.2.19 Identified Community Leaders

Figure B.19 summarizes the community leaders identified by respondents. From Figure B.19, the following observations can be made:

- Overall, 35% of the respondents identified an individual (e.g., a neighbor) as the person who can speak for the community, followed by 27% of the respondents who identified the city mayor, a representative from the homeowner association/community center (15% of the respondents), a city council member/local representative (8% of the respondents), and a church pastor (3% of the respondents).
- The gathered responses also revealed that 44% of the respondents surveyed at Site 1 (Pflugerville) and 45% of the respondents surveyed at Site 3 (Manor) identified the city major as the person who could speak for the community. Also of interest is the fact that 67% and 56% of the respondents surveyed at Site 4 (FM-973 & FM-812) and Site 5 (FM-973 & SH-71), respectively, identified a specific individual that could speak on behalf of the community. Sites 4 and 5 are smaller EJ communities.



Community leaders identified by respondents	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Individual (e.g., neighbor)	12	33%	8	36%	20	35%
City mayor	14	38%	2	9%	16	27%
Homeowners association/Community center	2	5%	7	32%	9	15%
City council member/Local representative	3	8%	2	9%	5	8%
Church pastor	0	0%	2	9%	2	3%
Did not provide name	6	16%	1	5%	7	12%
TOTAL =	37	100%	22	100%	59	100%

Survey Site	City mayor		City council member/Local representative		Individual (e.g., neighbor)		Homeowners association/Community center	
	Responses	Percent	Responses	Percent	Responses	Percent	Responses	Percent
Site 1	4	44%	1	11%	2	22%	2	22%
Site 2	2	15%	1	8%	3	23%	6	46%
Site 3	10	45%	2	9%	6	27%	0	0%
Site 4	0	0%	1	17%	4	67%	1	17%
Site 5	0	0%	0	0%	5	56%	0	0%

Survey Site	Church pastor		Did not provide name		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Site 1	0	0%	0	0%	9	100%
Site 2	0	0%	1	8%	13	100%
Site 3	0	0%	4	18%	22	100%
Site 4	0	0%	0	0%	6	100%
Site 5	2	22%	2	22%	9	100%

Figure B.19 Community Leaders

B.3 CONCLUDING REMARKS

The transportation mode used by those surveyed to get to work, school, grocery stores, and the hospital is the car, either driving alone (87% of the respondents) or carpooling (9% of the respondents). This suggests that minority and low-income communities also mainly rely on private cars to satisfy their transportation needs.

From the reported origin-destination travel patterns and the roads used by the respondents, it appears that the toll lanes being added to the median of the existing roads (i.e., US 290, US 183, and SH 71) will potentially have the most significant impacts on those surveyed. Besides I-35, the US 290, US 183, and SH 71 are the three major roads used by minority and low-income drivers to get to work, school, grocery stores, or the hospital.

About one-third of the respondents thus indicated that the proposed toll road(s) will affect (i.e., benefit or burden) the trips they make to work, school, grocery stores, or the hospital. The remaining 64% indicated that the toll road(s) will not affect their trips. Of those that indicated an impact on the trips they make, 35% of the responses reported an impact on trips to work, followed by travel to hospitals (30% of the responses) and grocery stores (28% of the responses). The less affected trips are to school (7% of the responses). Also, of those that indicated that the toll road(s) will impact their trips, 73% foresaw that the impact would be negative (i.e., burden) and 27% foresaw that the impact would be positive (i.e., benefit).

The respondents foresaw that the proposed toll road(s) will increase their travel cost (39% of the responses), travel time (18% of the responses), limit the number of their discretionary trips (7% of the responses), and force drivers to find alternative roads to avoid the toll (7% of the responses). On the other hand, some respondents recognized that the added toll capacity will reduce travel time and distance (16% of the responses) and alleviate congestion on existing roads (9% of the responses), especially on I-35 and FM 973. Finally, respondents did not foresee that SH 130 would provide them with an alternative road to satisfy their transportation needs and only 3% of those surveyed about the toll road system in Central Texas foresaw that the toll system would provide them with alternative roads(s) to satisfy their transportation needs.

Compare to the 33% of the respondents (80) that indicated that the proposed toll road(s) will affect their trips, more than 70% (169) indicated that the proposed toll road will impact their community. Similar results were obtained irrespective of whether the questionnaire pertained to SH 130 toll road or to the system of toll roads in Central Texas.

Of the 240 respondents overall, 114 respondents (48%) indicated that the proposed toll road(s) will benefit their communities, while 58 respondents (24%) did not foresee that the toll road(s) will benefit their communities. About 68 respondents (28%) refused to answer or did not know whether the proposed toll road(s) will benefit their communities. A higher percentage refused to answer or did not know whether the toll road system in Central Texas will benefit their communities compared to the SH 130 toll road. This is especially true for people surveyed regarding the proposed Central Texas toll road system (i.e., 34% of respondents did not know or refused to answer whether the proposed toll road system will benefit their communities).

The data analysis further revealed that 112 of the respondents (47%) indicated that the toll road(s) will impose a burden on their communities, while 58 of the respondents (24%) did not foresee any burden imposed by the toll road(s) on their communities. Seventy of the respondents (29%) refused to answer the question or did not know when asked if the toll road(s) will burden their communities.

The respondents provided 106 responses when asked to list the foreseen benefit associated with the toll road(s) on their communities. The respondents indicated that the toll road(s) will improve mobility (73% of the responses), provide social and economic benefits to the region (25% of the responses), enhance the environment (1% of the responses), and improve highway safety (1% of the responses). Of the 106 responses, 43% of the responses concerned the reduction of traffic on congested roads, specifically on I-35, SH 290 and Loop 1; 21% referred to the new toll road(s) providing a faster road to drivers; and 26% of the responses stated that the new toll road(s) will attract new businesses to the region (22%) and increase property values (4%).

The respondents provided 109 responses when asked to list the foreseen burdens imposed by the toll road(s) on their communities. The most often cited burdens were negative social and economic impacts on the community (78% of the responses), worsened mobility conditions in the area (15% of the responses), harm to the physical environment (6% of the responses), and reduced highway safety (2% of the response). The most often cited social and economic burden was the impact that toll road(s) will have on the families' budget because drivers have to pay for using the toll road(s). Also, a number of respondents were concerned that the toll road(s) will negatively impact the quality of life in their communities by attracting more people to the area.

Overall, the respondents provided 55 responses when asked about potential mitigation options to avoid or lessen any negative impact toll road(s) may have on their communities. The most often cited mitigation option was to not build toll roads or continue to pay for roads with tax dollars (44% of the responses). Also, a number of respondents said that the toll road decision should be put up to a vote (11% of the responses). The respondents also mentioned the need for better community outreach to inform and involve the community in the planning, design, and construction of toll road(s) (9% of the responses). Respondents further listed as mitigation options improvement of the connectivity and safety of the existing non-toll roads (9% of the responses) and the provision of better public transportation in low-income areas (5% of the responses) so that those who cannot afford the toll may have comparable alternatives to satisfy their transportation needs. Other mitigation options provided by respondents included providing "free passes" to those living near toll road and low-income people who cannot afford the toll, charging reasonable toll fees, building noise walls, and relocating affected properties.

The 112 respondents who indicated that toll road(s) will burden their community provided 65 measures (responses) to mitigate or avoid the negative impacts. This question had a relatively low response rate, which might suggest the need for additional outreach activities to inform and involve EJ communities in the decision-making process surrounding toll road(s) in Central Texas.

Overall, 77% of the respondents (184) indicated that they were amenable to being contacted in the future to provide input in the decision-making process surrounding toll road(s). The remaining 23% of the respondents did not want to be contacted in the future.

One of the core principles of the Environmental Justice Evaluation Methodology (EJEM) is the meaningful involvement of minority and low-income communities impacted by proposed toll road(s) in the decision-making process surrounding such projects. In this regard, the door-to-door survey revealed that community participation techniques preferred by most respondents were 'phone me' (43% of the responses), 'send a questionnaire' (28% of the responses), and 'come to my home' (20% of the responses). A few respondents (3% of the responses) preferred 'interview me at the shopping mall/grocery store', 'come to my church', or 'come to one of the schools in the community'. Also, 7% of the respondents indicated that the best way to contact them was through electronic mail (i.e., Internet). Furthermore, only 25% of the respondents (59) indicated that there was someone in the community that could speak for the community. The answers to this question were, however, site specific. In Manor, for example, 37% of the respondents said that there was someone that could speak for the community. On the other hand, 60% of the respondents of Site 1 (Pflugerville), Site 4 (FM-973 & FM-812), and Site 5 (FM-973 & SH-71) said that there was no one that could speak for the community. Overall, 35% of the respondents identified a neighbor who can speak for the community followed by 27% of the respondents who identified the city mayor, a representative from the homeowner associations/community center (15% of the respondents), a city council member/local representative (8% of the respondents), or a church pastor (3% of the respondents).

Over 80% of the respondents who indicated that the proposed toll road(s) will impact their trips and 78% of the respondents who indicated that the proposed toll road(s) will burden their communities indicated a willingness to provide input in the decision-making process surrounding toll road(s) in Central Texas in the future.

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Vita

Isabel C. Victoria-Jaramillo was born in Palmira, Colombia on August 7, 1965, the daughter of Leonel Victoria and Isabel Jaramillo. After completing her work at Champagnat High School, Palmira, Colombia, in 1982, she enrolled in the Universidad del Cauca, Colombia, where she received a degree of Bachelor of Science in Civil Engineering in December, 1987. Upon graduation, she pursued post-graduate studies at the Universidad of Puerto Rico at Mayaguez. In December, 1991, she graduated with a Master of Science in Civil Engineering since Transportation Engineering her field of specialization. From 1992 to 2000, she worked as an Assistant to the Executive Director at the Puerto Rico Highway and Transportation Authority. In August, 2001, she went on to pursue a doctoral degree at the University of Texas at Austin.

Permanent address: 3356 Lake Austin Blvd, Apt. E
Austin, TX 78703

This dissertation was typed by the author.